MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL TECHNICAL UNIVERSITY
"KHARKIV POLYTECHNIC INSTITUTE"

TASKSAND EXERCISES ON DESCRIPTIVE GEOMETRY

for practical training and independent work
of specialty oil and gas engineering and technology students

МЕТОДИЧНІ ВКАЗІВКИ

для аудиторної та самостійної робот студентів спеціальності
«Нафтогазова інженерія та технології»

Затверджено
редакційно-видавничою
радою університету
протокол № 1від 22.06.2017

Kharkiv
NTU "KhPI"
2018

Tasksandandexercisesondescriptivegeometry методичні вказівки для аудиторних занять та самостійної роботи студентів спеціальності нафтогазової інженерії та технології/Уклад. ШоманО.В., СавченкоЛ.М.,ДаниленкоВ.Я., ВоронцоваД.В. – Харків: НТУ «ХПІ»,2018. –52с.

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ALBUM OF THE ASSIGNMENTS

Table 1

№ of the Assignments	Name of the Assignments	Formats of theAssignments	Balls
STANDARDS			
1	Album of the Assignments	A3	10
2	Geometricconstructions of the Shaftand the Gasket	A4	10
ORTHOGRAPHICAL PROJECTIONS OF A POINT, LINE AND PLANE			
3	Positional and metric problems	A3	10
SOLIDS			
4	Solids and section (polyhedrons)	A3	10
5	Solids and sections (figures of revolution)	A3	10
6	Axonometric drawings	A4	10
PROJECTIONS WITH ELEVATIONS			
7	Projection of Topographical Surfaces	A4	10
COMPUTER DRAWINGS			
8	Geometric constructions of theShaftand a Gasket	A4	10
9	Solids and section (polyhedrons)	A4	10
10	Solids and sections (figures of revolution)	A3	10

List of all assignments are represented in the Table 1.

Part1

USDD STANDARDS, REQUIREMENTS FOR IMPLEMENTATION OF ASSIGMENTS

***USDD** - Uniform system of design documentation; **GOST** – state standard specification*

1. THE FORMATS.

Fill the Table2 according to GOST 2.301-68.

Table 2

FORMATS				
A0	A1	A2	A3	A4
841 × 1189				

2. SCALES.

Fill the Table3 according to GOST 2.302-68.

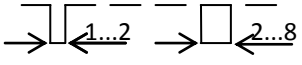
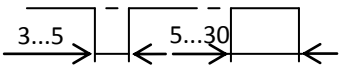
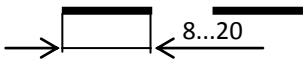
Table 3

Actual size	1 : 1;
The scales of reduction	1 : 2; 1 : 2,5;
The enlargement scales	2 : 1; 2,5 : 1;

3. TYPES OF LINES.

Fill the Table 4 according to GOST 2.303-68.

Table 4

Name	Image		Thickness of the line relative to the thickness of a solid main line
The solid main			S
The solid thin			S/3 … S/2
The solid wavy			S/3 … S/2
The dashed			S/3 … S/2
Dash-dotted slim			S/3 … S/2
The disconnected			S … 1,5S

4. FONT TYPES.

The Font Type B with a slope 75 ° is represented at Figure 1.1according to GOST 2.304-81.

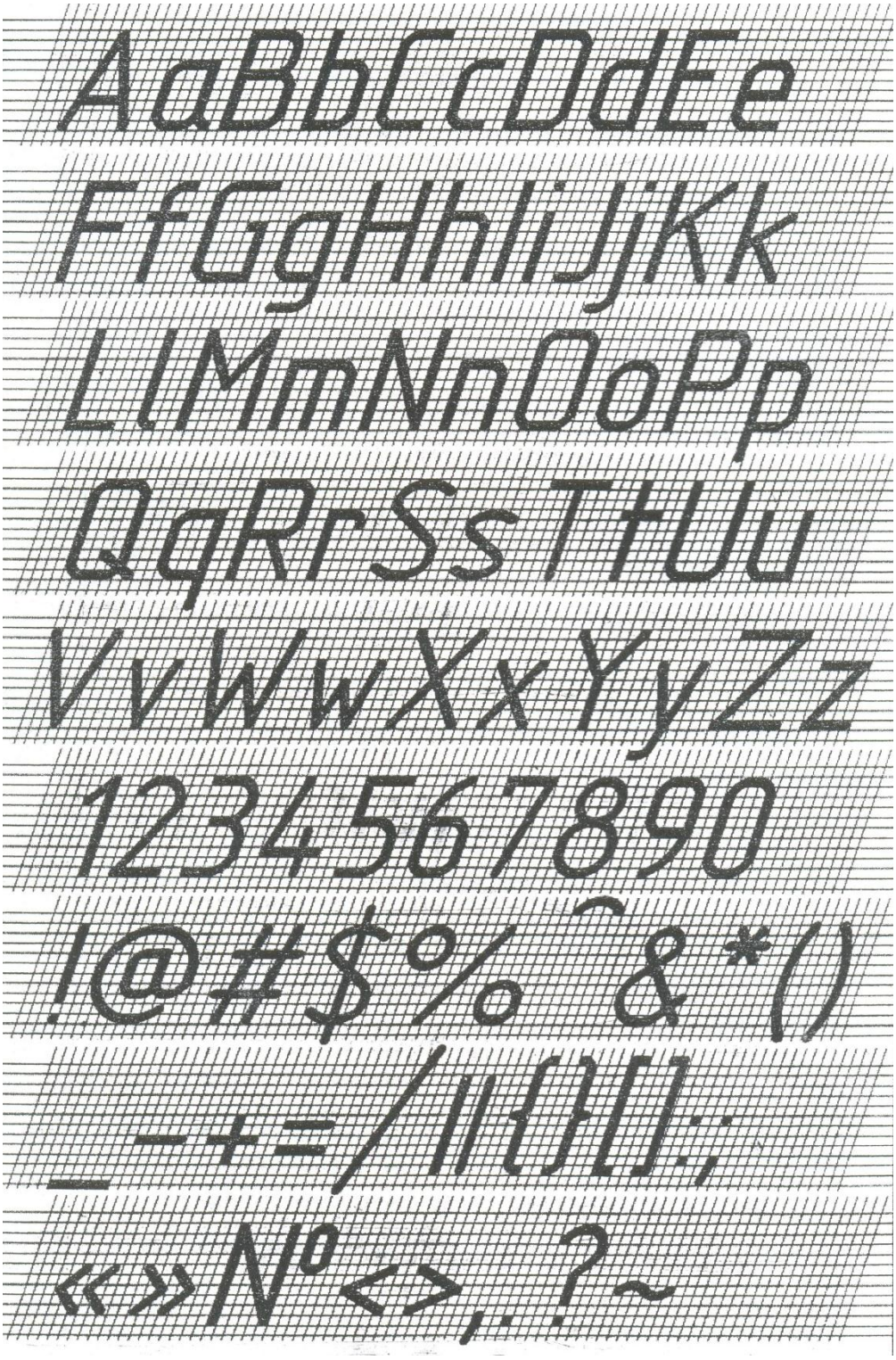


Fig. 1.1. The Font type B with a slope 75 °

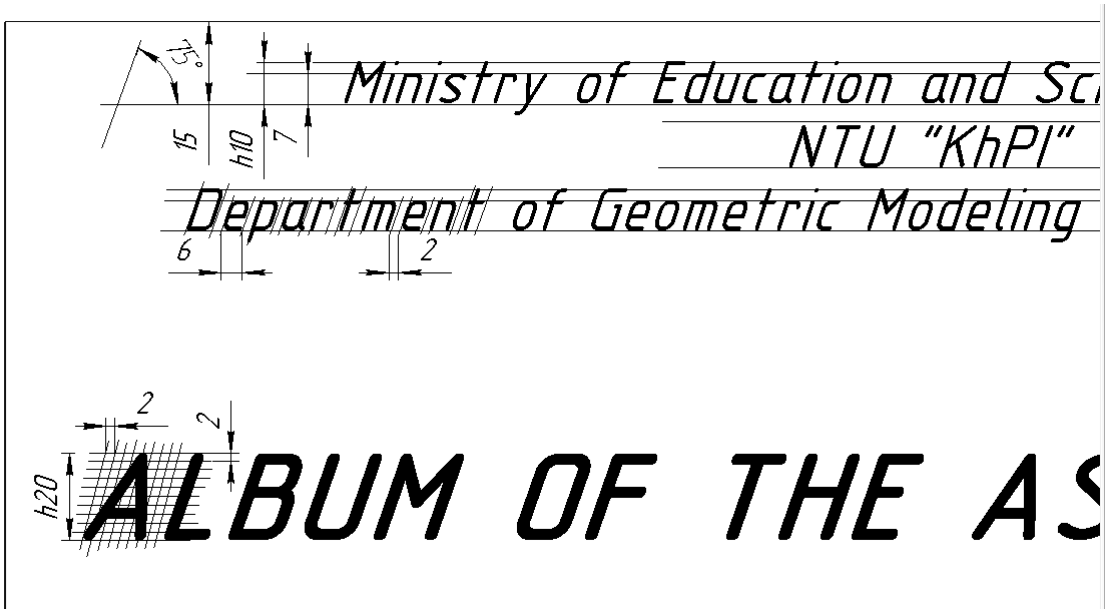


Fig. 1.2.The Example of Title Page segment

Table 5

Font parameters	Design.	Dimensions, mm									
Size of Font	*h*	1,8	2,5	3,5	5	7	10	14	20	28	40
High of capital letters	*h*	1,8	2,5	3,5	5	7	10	14	20	28	40
High of lowercase letters	*c*	1,3	1,8	2,5	3,5	5	7	10	14	20	28
Line width	*d*	0,18	0,25	0,35	0,5	0,7	1,0	1,4	2	2,8	4,0
Letter width	*g*	1,1	1,5	2,1	3	4,2	6	8,4	12	16,8	24
Distance between letters	*a*	0,3	0,5	0,7	1,0	1,4	2,0	2,8	4,0	5,7	8
Minimum line pitch	*b*	3,1	4,3	6,0	8,5	12	17	24	34	47,6	68
Minimum distance between worlds	*e*	1,1	1,5	2,1	3	4,2	6	8,4	12	16,8	24

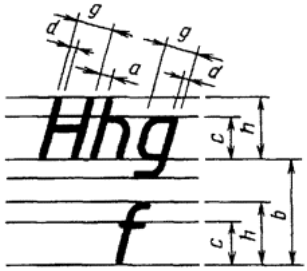


Fig. 1.3. The Example ofFont B

HOMEWORK

Draw a Title Page "ALBUM OF THE ASSIGMENTS" by Font Type B with a slope 75 °.Use all parameters from Table 5 and Figures 1.2, 1.3. The example of the Title Page is represented in Annex 1.

5. GEOMETRICCONSTRICTIONS OF SHAFTAND GASKET.

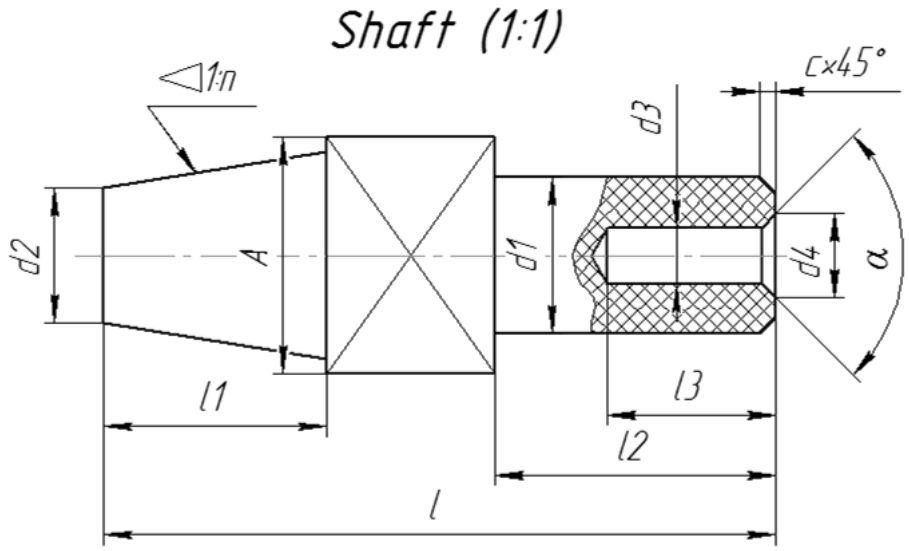


Fig. 1.4. The Shaft drawing

Table 6

option	A	d1	d2	d3	d4	L	l1	l2	l3	α	c	n	scale
1,9	Ø40	30	20	8	15	110	30	55	25	60	2	3	1:1
2,10	□42	28	24	10	15	130	40	60	30	90	3	5	1:1
3,11	Ø84	56	48	20	30	260	80	120	60	60	6	5	1:2
4,12	Ø105	70	60	25	35	325	100	150	75	60	7,5	5	1:2,5
5,13	□80	60	40	16	30	220	60	110	50	90	4	3	1:2
6,14	□100	75	60	20	37,5	275	75	125	60	90	5	3	1:2,5
7,15	Ø160	120	80	32	60	440	120	220	100	60	8	3	1:4
8,16	□140	112	96	40	60	520	160	240	120	90	12	5	1:4

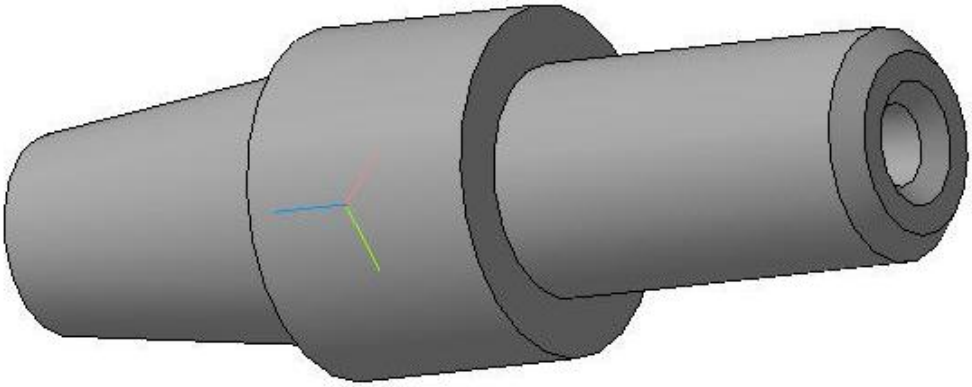


Fig. 1.5. The Shaft 3D model

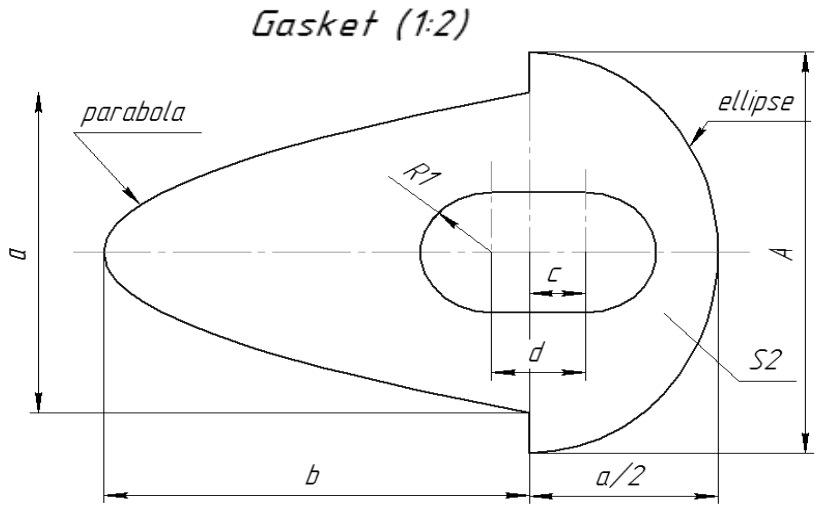


Fig. 1.6. The Gasket drawing

Table 7

Option	a	b	c	d	R1	A	scale
1,9	80	100	10	25	12	100	1:1
2,10	70	110	10	20	12	90	1:1
3,11	160	200	20	50	24	200	1:2
4,12	80	90	12	20	16	100	1:1
5,13	60	120	15	30	10	90	1:1
6,14	160	180	24	40	30	200	1:2
7,15	90	110	15	30	12	100	1:1
8,16	45	60	5	10	6	50	2:1

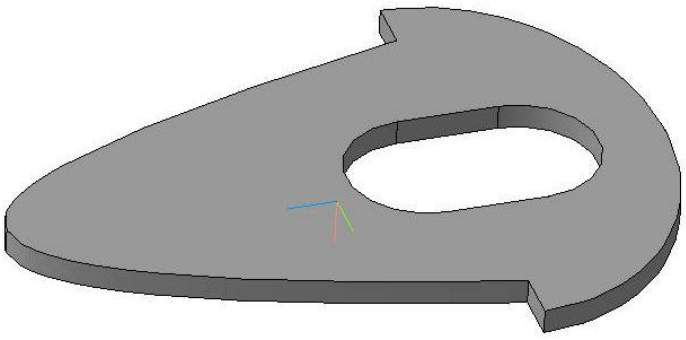


Fig. 1.7. The Gasket 3D model

HOMEWORK

Make a drawing of a Shaft and a Gasket. Use all parameters from Table 6, 7 and Figures 1.4 - 1.7. The example of the drawing is represented in Annex 2.

Part2

ORTHOGONAL PROJECTIONS OF GEOMETRICAL ELEMENTS. METHODS OF TRANSFORMATION.

Section 1

ORTHOGRAPHICAL PROJECTIONS OF A POINT

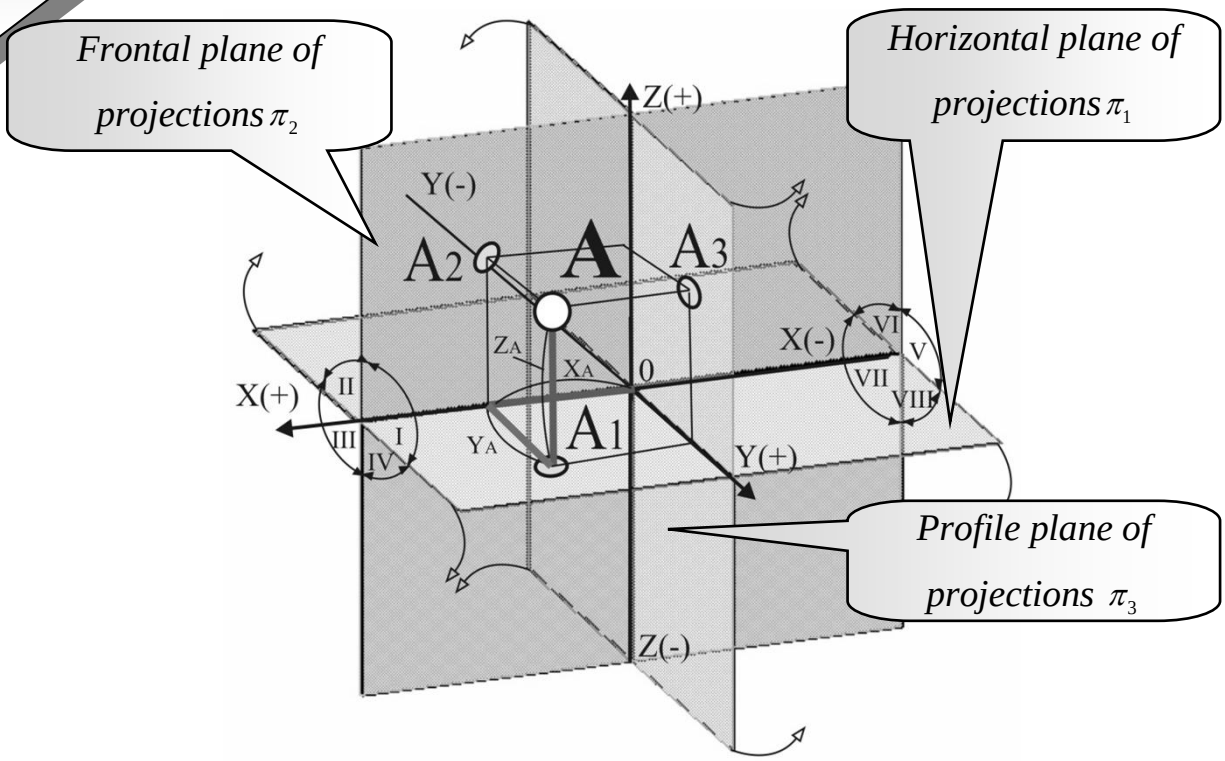


Fig. 2.1.The conditional and perspective drawing

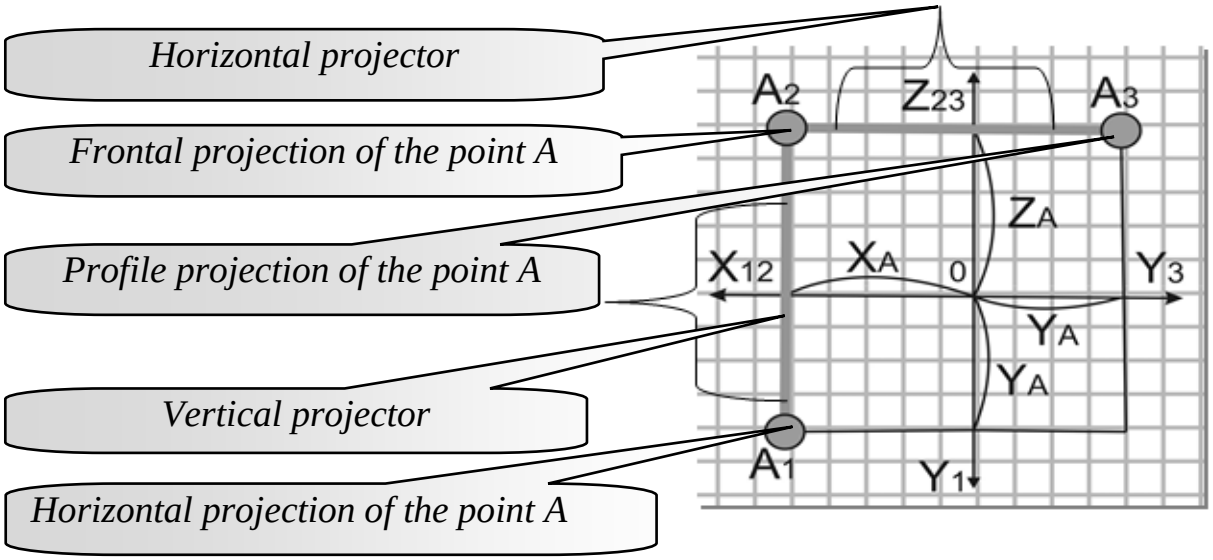


Fig. 2.2.Orthographic drawing (Monge's drawing)

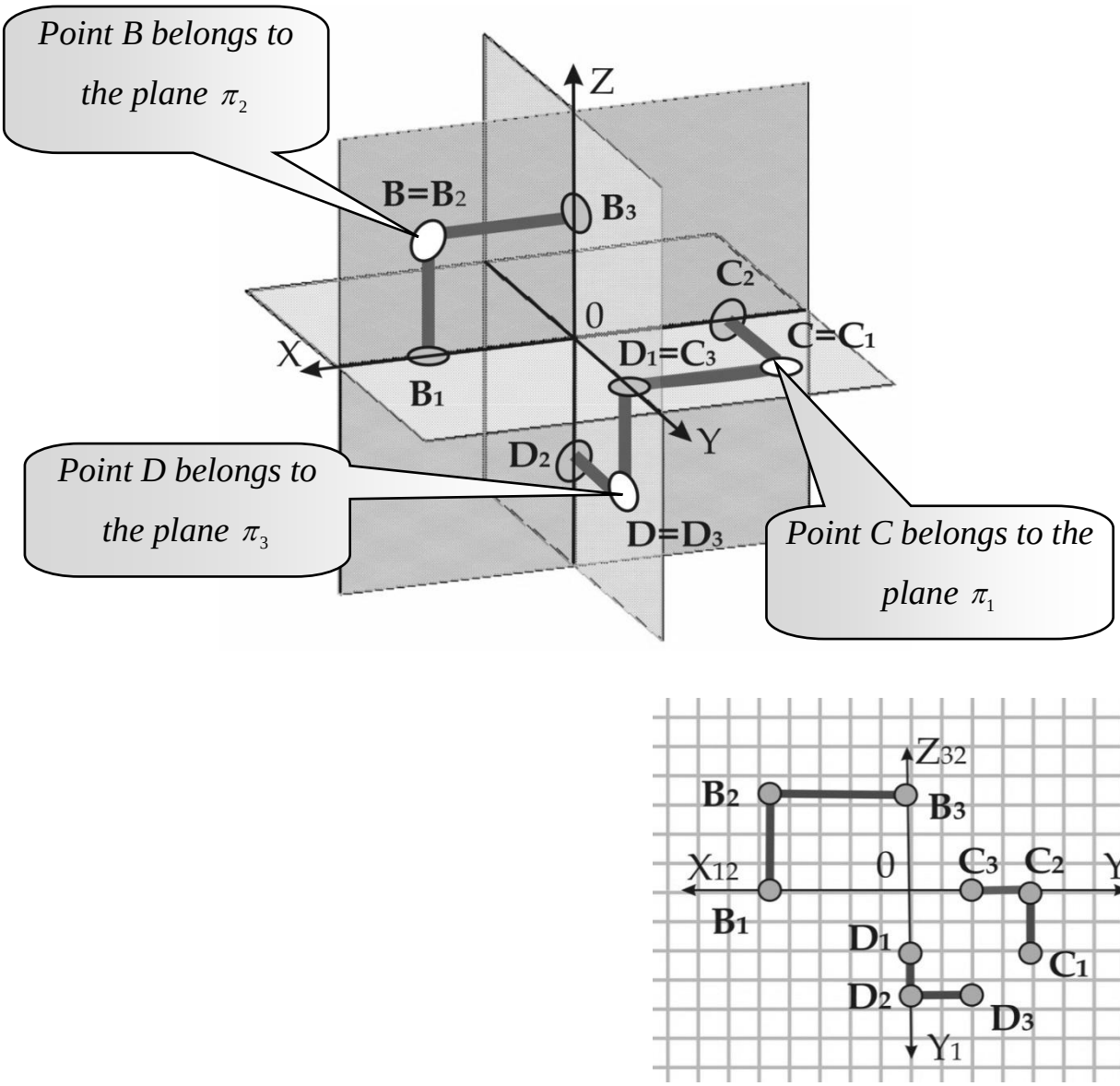
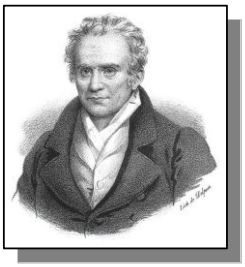


Fig. 2.3.Orthographic projection of the point



Monge Gaspard, french mathematician and geometer 1746-1818

Descriptive geometry as a science was established the end of XVIII century the great French geometer and engineer Gaspard Monge (1746-1818).

The first idea of orthogonal projection on the plane of spatial figures expressed long before the Monge in the XVI century German mathematician and artist Albrecht Dürer (1471-1528), who developed the method of orthogonal image conic sections and some spatial curves.

In 1637, the French geometer i philosopher Rene Descartes (1596-1650) created a method of coordinate i laid the foundations of analytical geometry and his compatriot, engineer and mathematician Dezah Girard (1593-1662) used this method to build a perspective coordinate projections and established theory axonometric projections.

Answerthefollowingquestions!

1. *Theprojection of the point is* _____ (Fig. 1.1)?

2. Write down the coordinates which determine*frontal, horizontal and profile projection of a point*A_1(,), A_2(,), A_3(,)(Fig. 1.2)?

3. In what case the point belongs to the plane Π_3_____, Π_1 _____ andΠ_2 _____ (Fig. 1.3)?

4. What *coordinates* determine the distance from the point to the frontal plane of projections _____ to the horizontal plane of projections _____, to the profile plane of projections _____?

5. In what casethepoint will be *equally spaced*fromthe planes of projections Π_1 and Π_2_____?

6. In what case thepoints*A* and *B* will be located at the same distance from the planeΠ_1_____?

Problem 2.1

For given points:

1. Constructtheorthographic drawing.

2. Determine location of the points with respect to the planes of projections (fill the table 8).

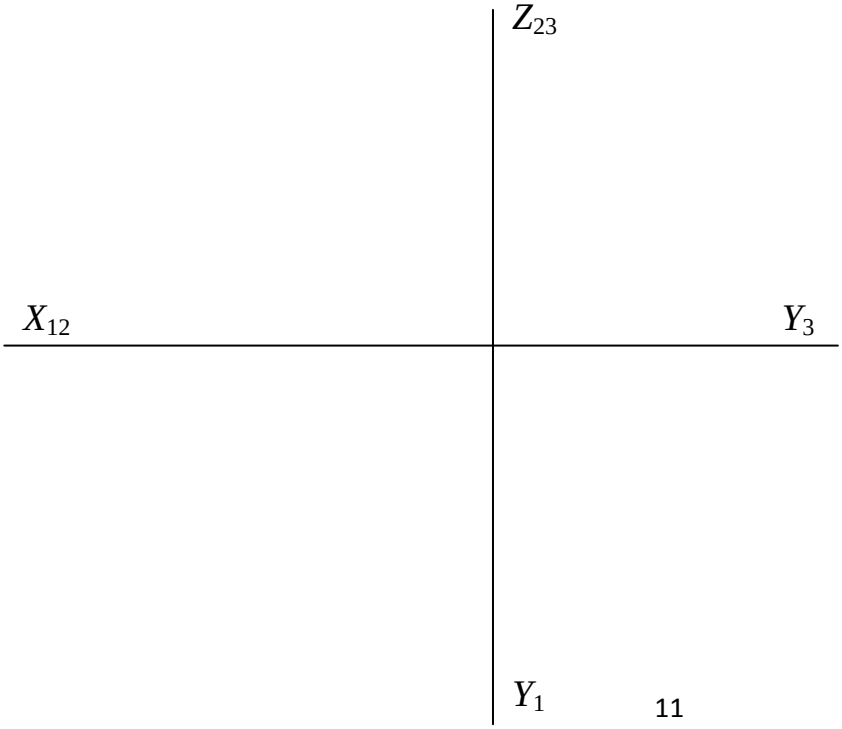
3. Indicate theplanesof projectionsthepoint E are equally spaced from _____, the point G_____, the point K_____?

4. Find the point which is highest _____and lowest _____.

5. Which the of points have the same distance to the profile plane of projections _____ to the frontal plane projections _____?

Table 8

Coordinates ofpoints	Locations
A(10,20,30)	
B(−30,10,20)	
C(0,−40,−10)	
D(−20,0,−30)	
E(40,40,0)	
K(30,−20,20)	
L(−15−40,−10)	
G(25,25,−25)	



Answer the following question!

1. The First Projection Lawistells that_____
_____
_____

2. The *Second Projection Law* tells that_____
_____
_____

3. The T*hird Projection Law* tells that_____
_____
_____

Problem 2.2

1. Construct on the Orthographic drawings the Missing Projections of Points.**2**. Determine the Coordinates and Locations of each Point. Fill the Table 9.**3**. Identify points which are equally spaced from Π_1.

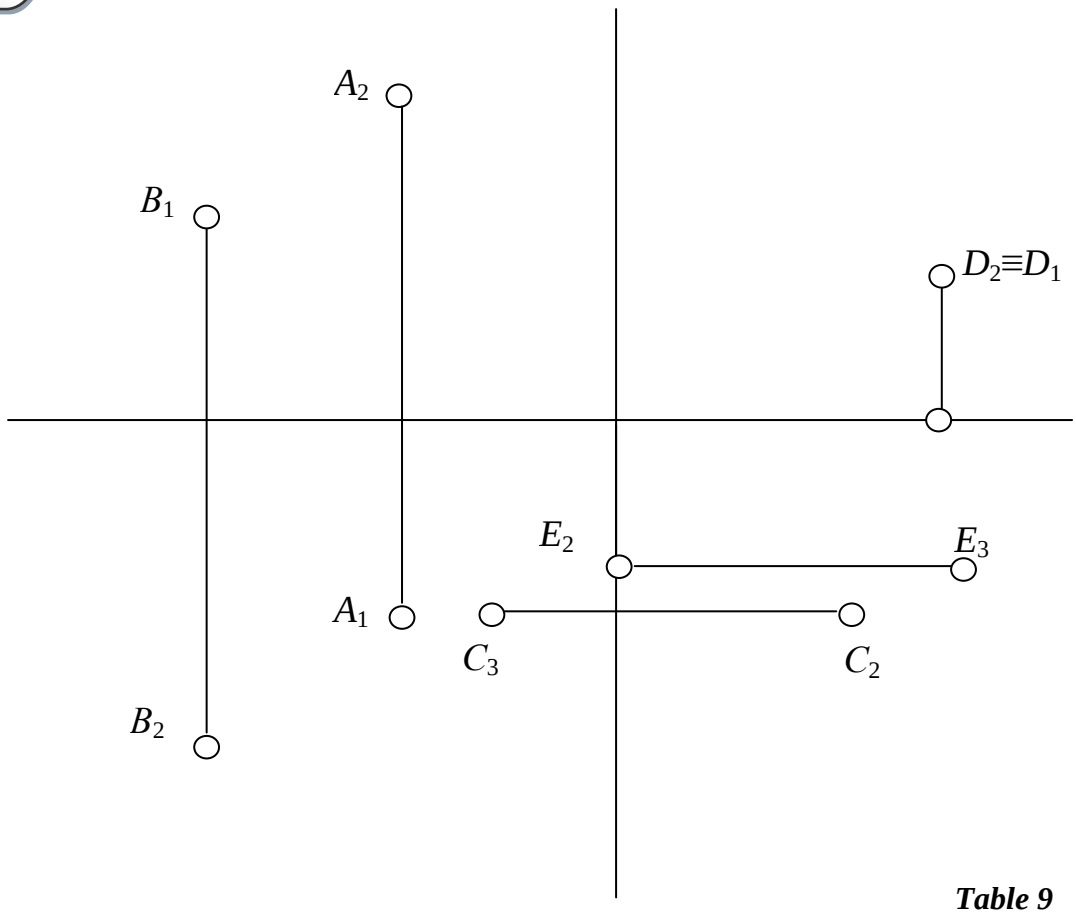


Table 9

Coordinates	*A*	*B*	*C*	*D*	*E*
X					
Y					
Z					
Locations					

CHAPTER 3

ORTHOGRAPHICAL PROJECTION OF A LINE

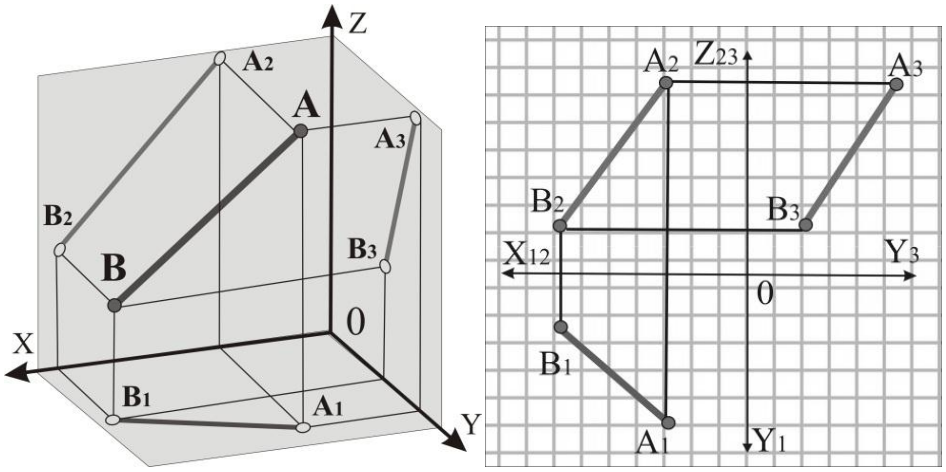


Fig.3.1. TheOblique line

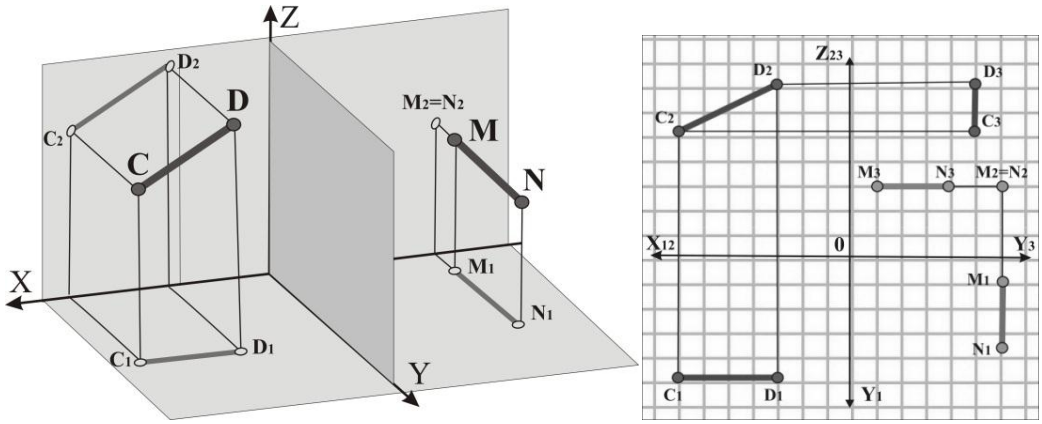


Fig.3.2. Thefrontaland the frontally projecting line

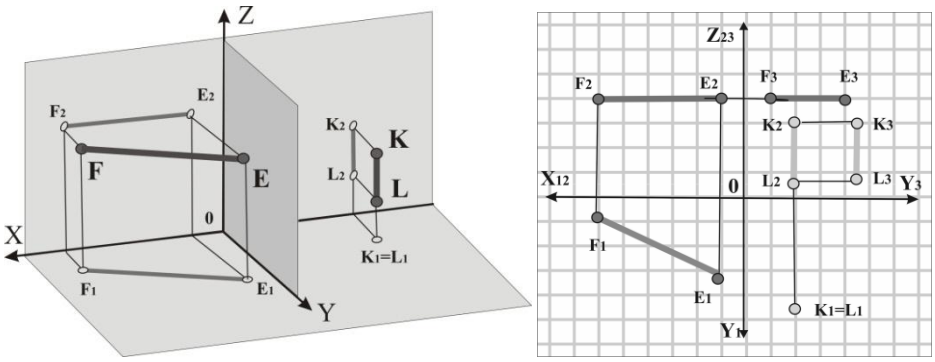


Fig.3.3. Thehorizontal and the horizontally projecting line

Answer the following questions!

1. What location does the Oblique line have with respect to the planes of Projections?(Fig. 3.1)What location does the Oblique line have with respect to the coordinate axes(⫽, ∥, ⊥, ⧸)?

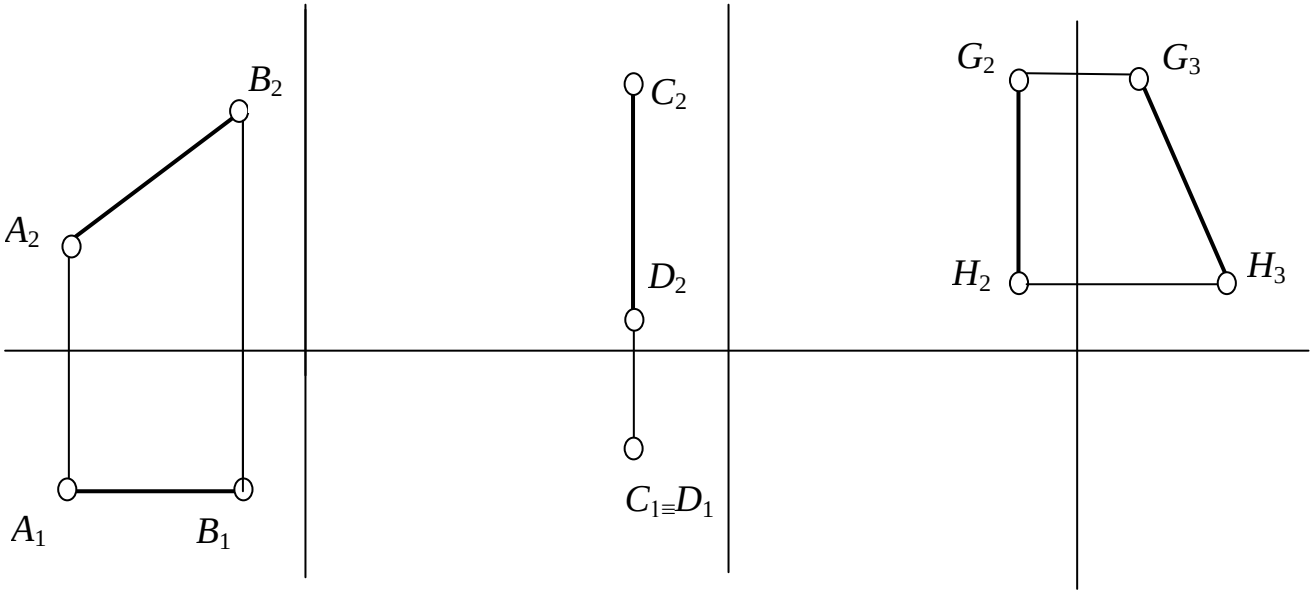
2. What are the frontal, horizontal and profile line (Fig. 3.2, 3.3)?What location does (⫽, ∥, ⊥, ⧸) the projections of frontal, horizontal and profile line have with respect to the coordinate axes:

- *thehorizontal*: F_1E_1___, F_2E_2___, F_3E_3____;
- *the frontal:* C_1D_1___, C_2D_2___, C_3D_3____;
- the*profile:*K_1L_1___, K_2L_2___, K_3L_3____?

3. What Type of the line projects into a point? (Fig. 3.2, 3.3)?

Problem 3.1

1. Construct a missing projection of the line segments.
2. Identify the type ofstraight line with respectto the planes of projections.
3. Find the true size and angles (α, β, γ)of each line?



_____ _____ _____

AB *CD* *G H*

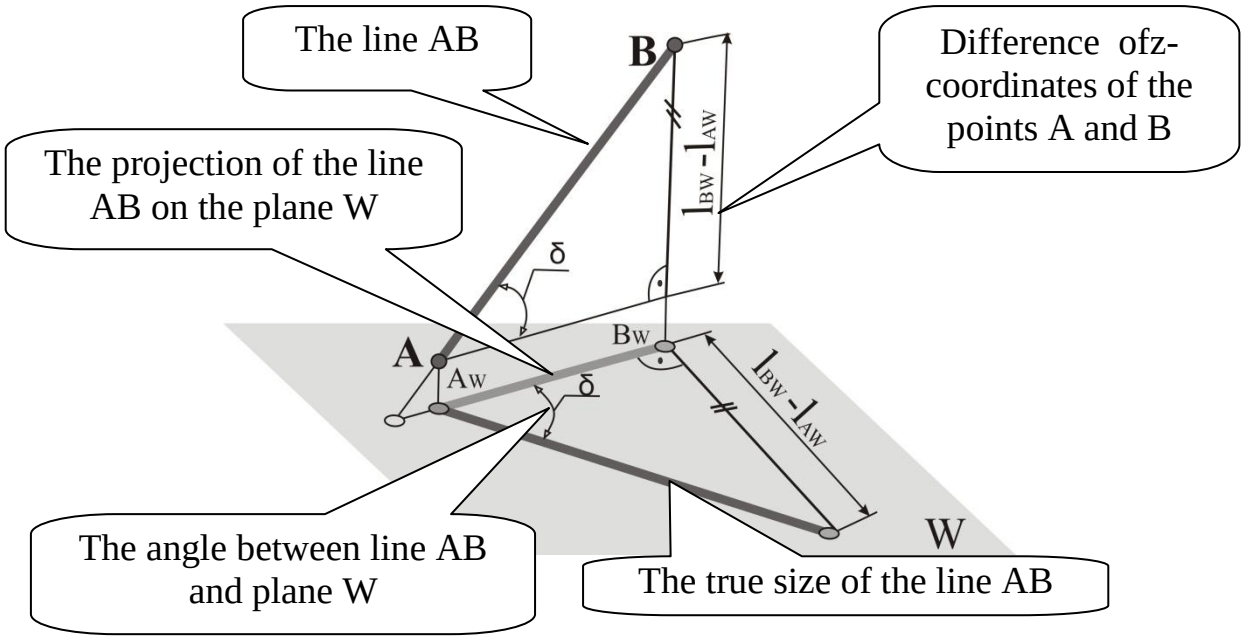


Fig. 3.4.The Truesize of Oblique line
(The rule ofthe right triangle)

Answer the following questions!

1.How to determine the *true size* of the Oblique line and anglesbetweenline and planes of projections on the orthographic drawings(Fig. 3.4)?

2.Whatistraceoftheline? Howmanytraces doeslinehave(Fig. 3.5, 3.6):

- *the Oblique line* _____;
- *the line parallel to the*planeofprojection_____ _____;
- *the line perpendicular*to theplaneofprojections_____ ____?

Problem 3.3

Construct the missing projection of the line AB and determine its true size and angles (α, β, γ). Fill the table 10.

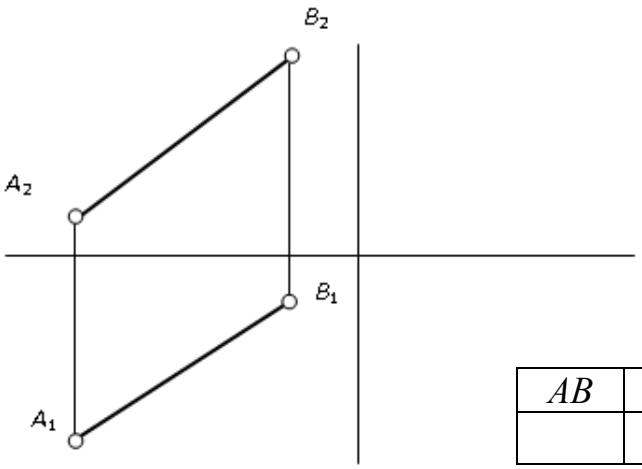


Table 10

AB	α	β	γ

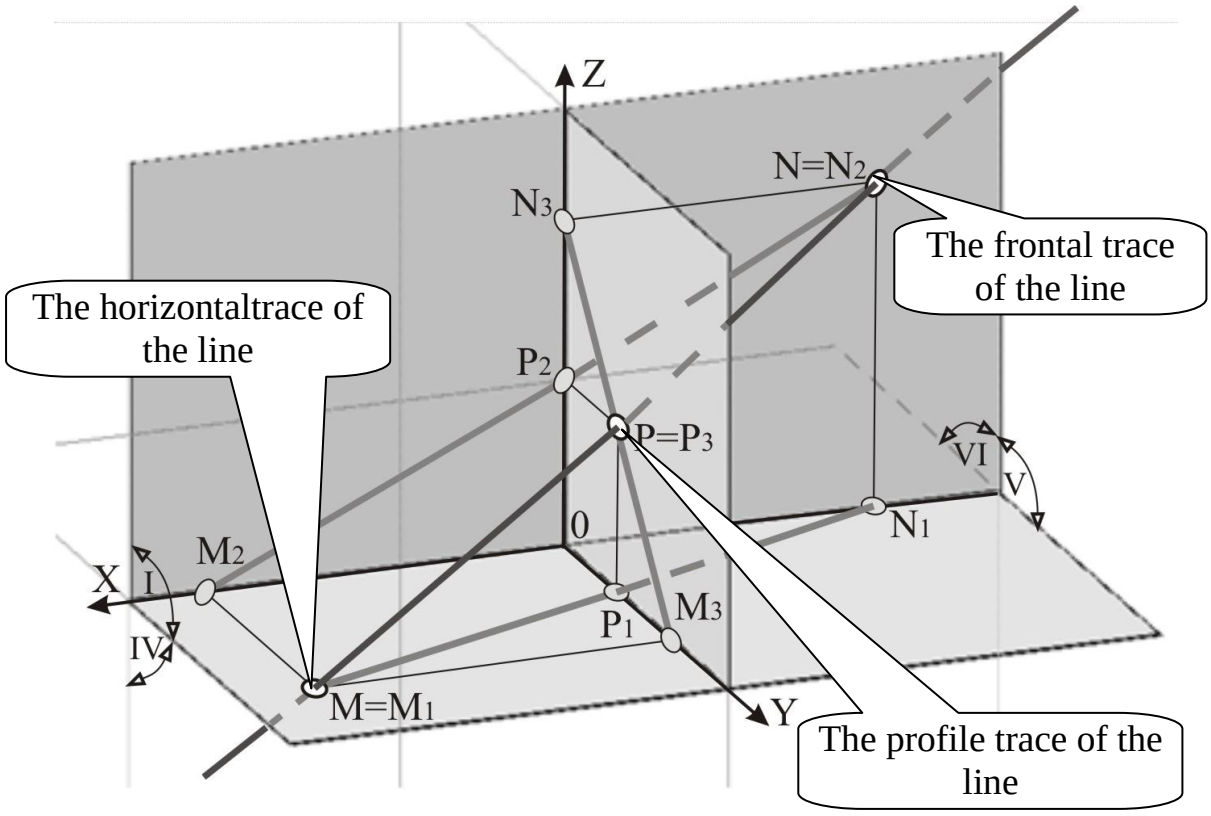


Fig. 3.5.Traces of the line

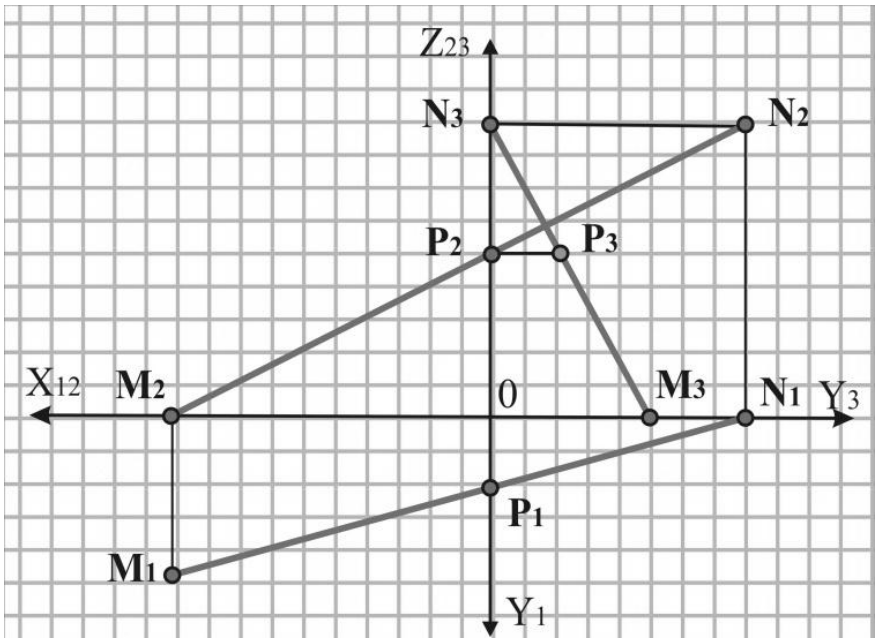


Fig. 3.6.Orthographic drawing of a Line

CHAPTER 4

ORTHOGRAPHICAL PROJECTIONS OF A PLANE

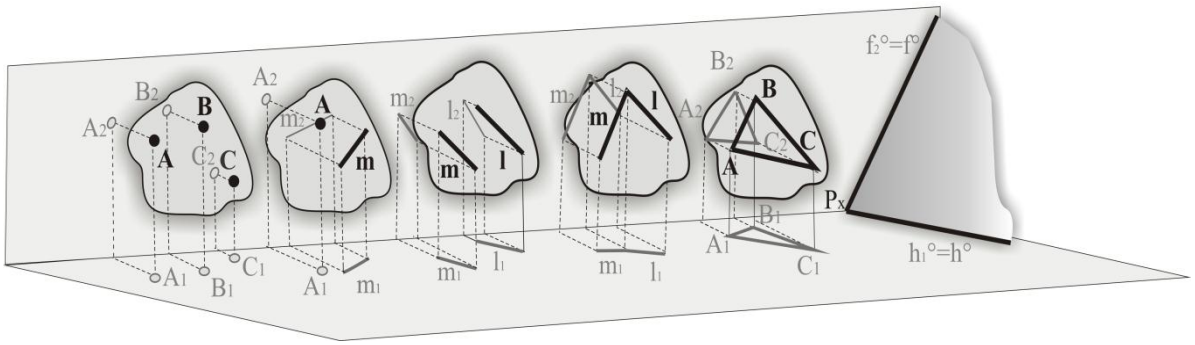


Fig. 4.1. Representationof the planes

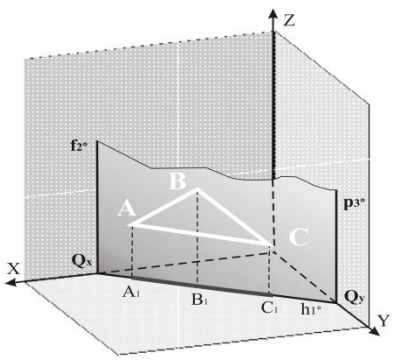


Fig. 4.2.Horizontally projecting plane

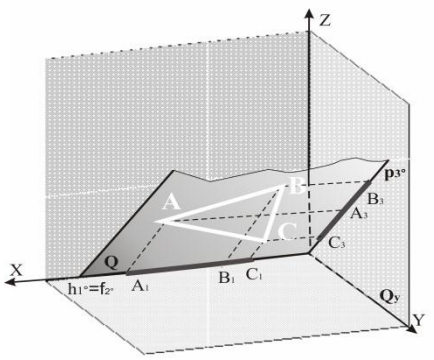


Fig. 4.3. Axial plane

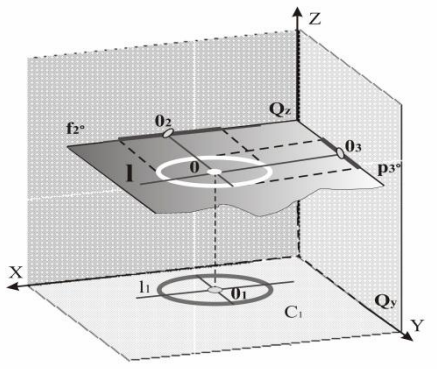


Fig. 4.4.The horizontal plane

Answer the following question!

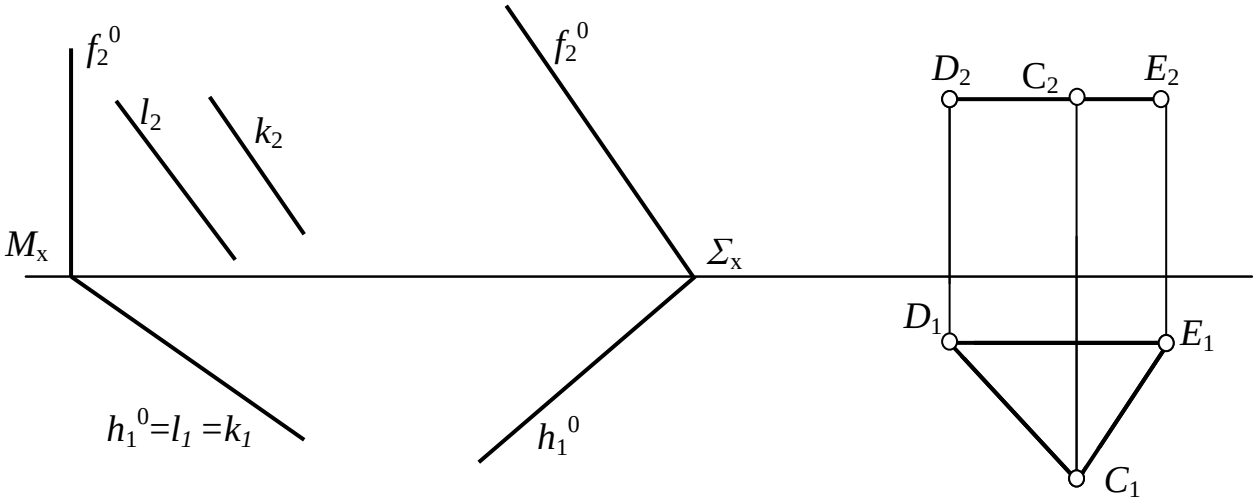
1. What location does the Oblique plane have with respect to the planes of Projections (Fig. 4.1)?

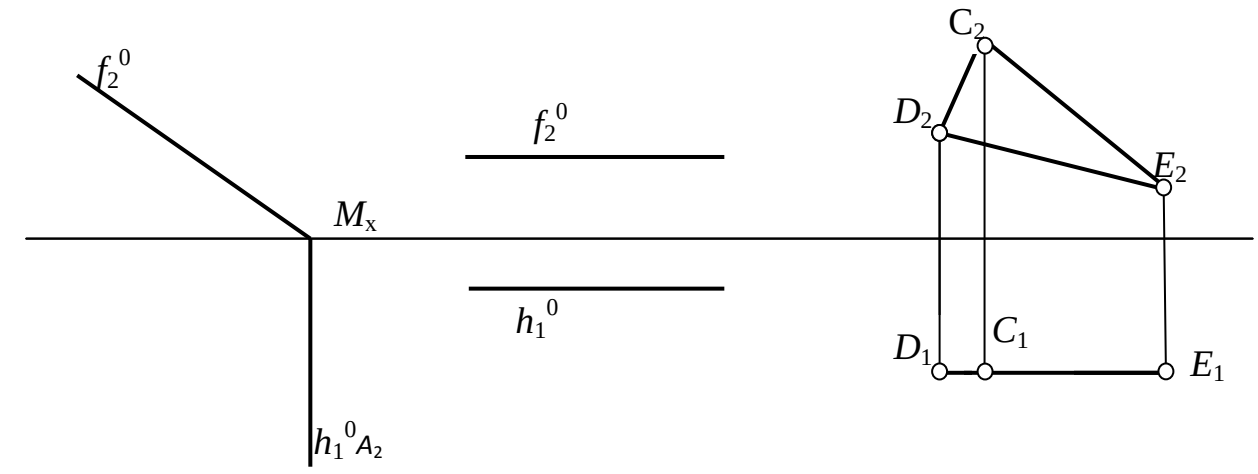
2. What Type of planeparallel to the planes of Projections (Fig. 4.4)? What property does it have?

3. In what case does thepoint belong to the plane? In which casedoes the line belong to the plane?

Speaking exercise 4.1

Determine location of each plane with respect to planes of Projections?





Problem 4.1

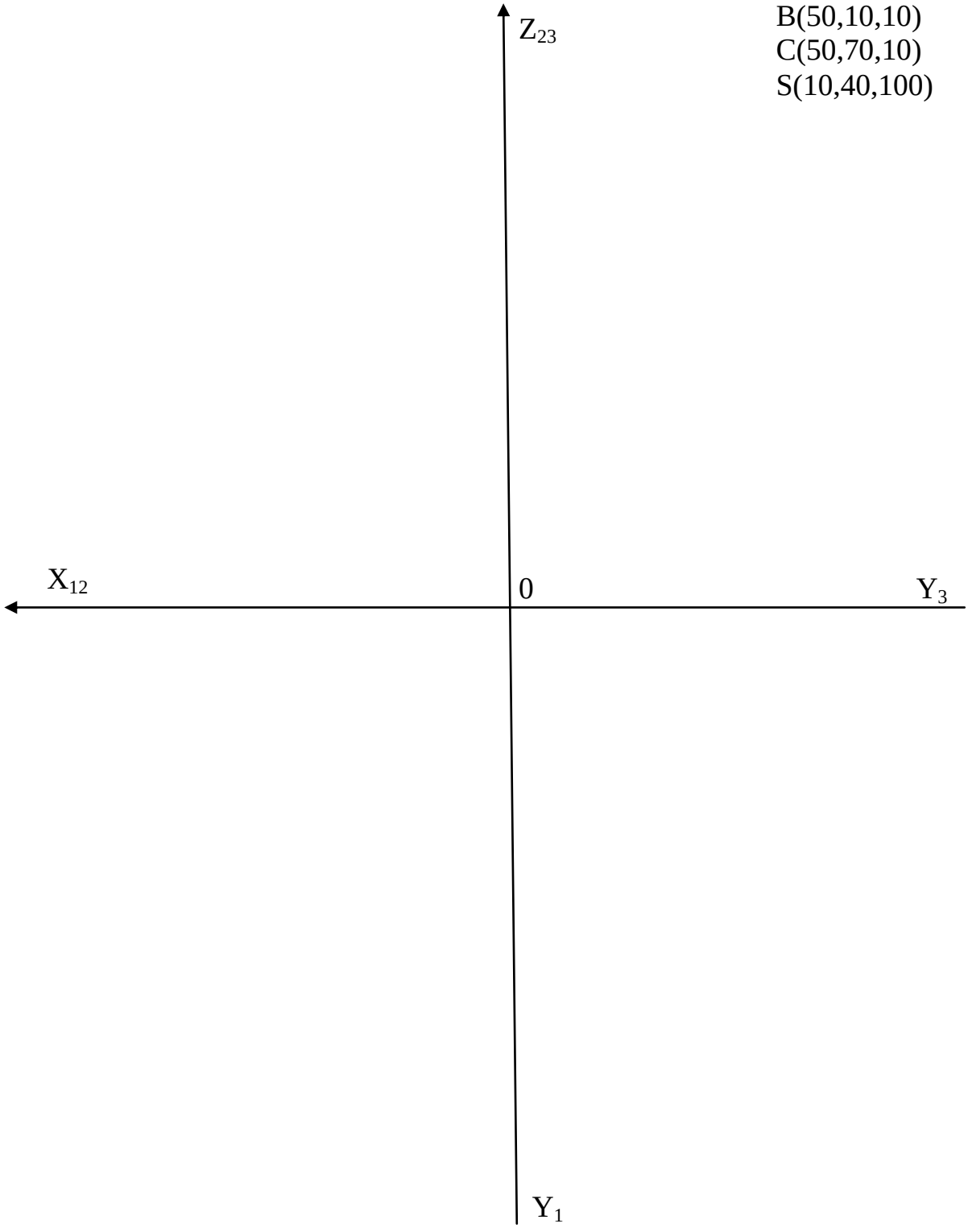
1. Construct three projections of the given points A, B,C,and S.
2. Join propertyprojectionsofthe given points.
3. Determine locations of the lines, which are ribs and sides of the pyramid.
4. Find a True size for the each line. For the Oblique lines use the method of the right-angled triangle. Fill the Table 11.
5. Determine the Types of the planes (sides and base of the pyramid) and fill the Table 11.
6. Construct the side development of the pyramid with the method of Triangle, conventionally cutting it through one of the ribs; then add the plane of the triangle ABC to any side of the base.

Table 11

Lines					
AS	BS	CS	AB	BC	AC

Planes			
ABC	SAB	SBC	SAC

A(130,40,10)
B(50,10,10)
C(50,70,10)
S(10,40,100)



HOMEWORK

Construct on the drawing paper A3 projections of points, lines and planes accordance with coordinates from the table 12. The example of the task 3 «Orthographical projections of a point, line and plane» is presented in Annex 3.

Table 12

Variant	A(X,Y,Z)	B(X,Y,Z)	C(X,Y,Z)	S(X,Y,Z)
1	120,10,10	120,70,10	20,40,10	120,40,100
2	120,70,10	10,70,10	10,10,10	10,70,100
3	65,10,10	120,70,10	10,70,10	65,40,100
4	70,10,10	120,70,10	15,70,10	40,70,100
5	15,65,10	105,10,10	105,55,10	15,65,100
6	15,10,10	15,70,10	115,40,10	115,40,100
7	110,40,10	20,70,10	20,10,10	20,40,100
8	110,70,10	90,10,10	20,70,10	90,40,100
9	130,40,10	50,10,10	50,70,10	10,40,100
10	40,70,10	120,40,10	70,10,10	10,40,100
11	20,70,10	110,70,10	70,10,10	20,70,100
12	110,70,10	110,10,10	10,10,10	60,40,100
13	100,10,10	10,10,10	60,70,10	60,10,100
14	100,60,10	100,10,10	10,10,10	10,60,100
15	110,10,10	40,10,10	40,60,10	10,10,100
16	110,10,10	10,10,10	60,70,10	60,40,100
17	120,10,10	120,70,10	10,30,10	120,30,100
18	110,70,10	15,70,10	15,10,10	15,70,105
19	70,10,10	130,70,10	10,70,10	85,50,100
20	120,65,10	20,65,10	70,10,10	95,65,100
21	100,65,10	100,10,10	20,65,10	20,65,100
22	115,30,10	15,10,10	5,70,10	115,30,100
23	20,70,10	20,10,10	100,50,10	20,50,100
24	15,70,10	110,70,10	50,10,10	50,40,100
25	40,70,10	120,40,10	40,10,10	10,40,100
26	80,10,10	40,70,10	115,40,10	10,40,100
27	40,10,10	15,70,10	100,70,10	15,70,100
28	110,10,10	10,10,10	110,70,10	35,25,100
29	65,70,10	115,10,10	5,10,10	65,70,100
30	15,10,10	100,60,10	100,10,10	15,60,100
31	120,10,10	120,70,10	20,40,10	120,40,100
32	120,70,10	10,70,10	10,10,10	10,70,100
33	65,10,10	120,70,10	10,70,10	65,40,100
34	70,10,10	120,70,10	15,70,10	40,70,100
35	15,65,10	105,10,10	105,55,10	15,65,100
36	15,10,10	15,70,10	115,40,10	115,40,100
37	110,40,10	20,70,10	20,10,10	20,40,100
38	110,70,10	90,10,10	20,70,10	90,40,100
39	130,40,10	50,10,10	50,70,10	10,40,100
40	120,10,10	120,70,10	20,40,10	120,40,100

Test your knowledge!*(The Example Card of the Test Control)*

Analyze Fig. 1and answer the questions 1-3.

1. What Octant The Point 1 is located in?
2. Which of the points belongs to the horizontal plane of projections?
3. What Plane of ProjectionThe Point 3 is equally spaced from?

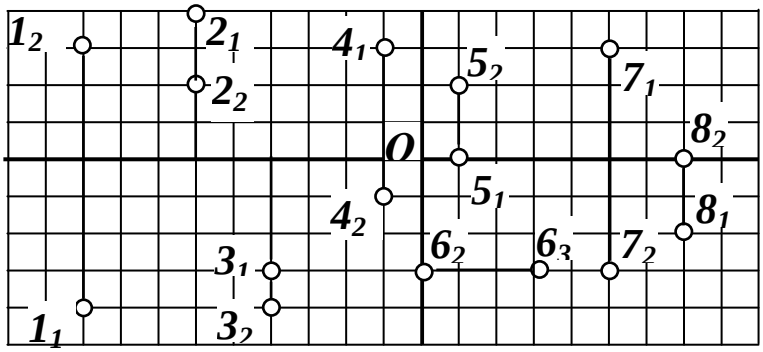


Fig. 1

Analyze Fig. 2 and answer the questions 4-6.

4. What segment of the line AG is parallel to horizontal plane of projections?
5. What segment of the line AG is perpendicular to the Vertical plane of Projection?
6. Which of Points is in front of Line AG?

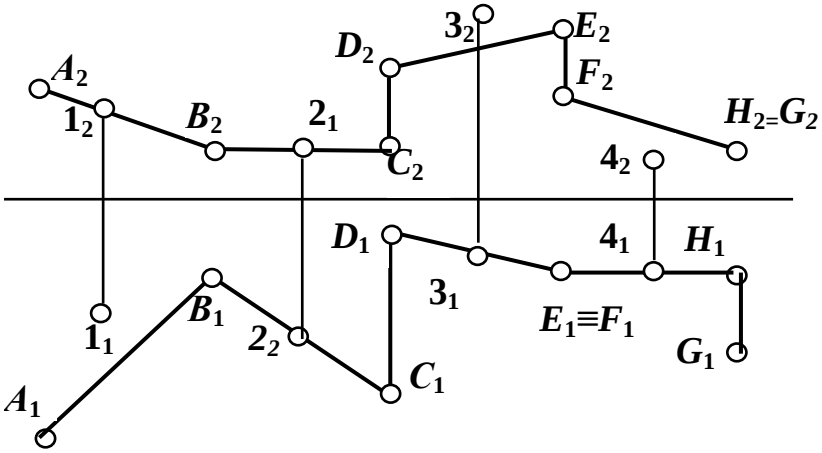


Fig. 2

Analyze Fig. 3 and answer the questions 7-9.

7. What is the name of horizontal projecting plane?

8. What is the name of Oblique plane?

9. What is the name of plane of horizontal level?

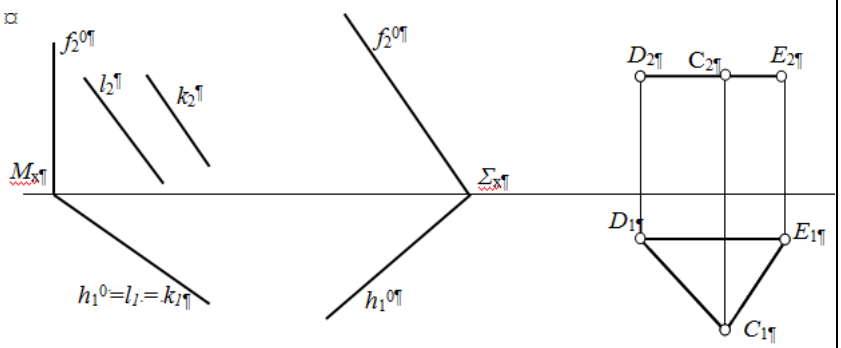


Fig. 3

Finde Theanswers on the Page 44

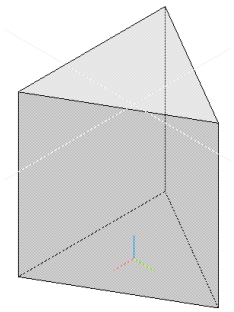
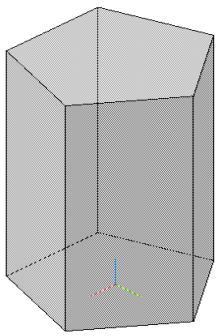
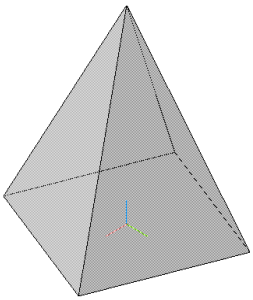
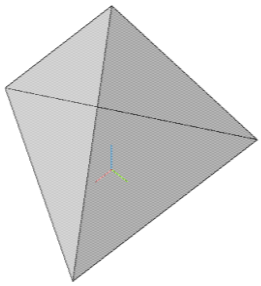
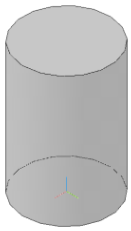
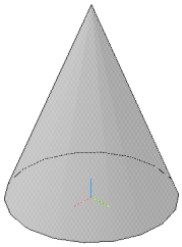
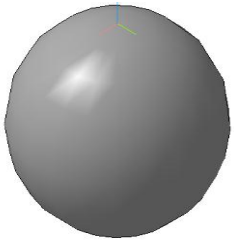
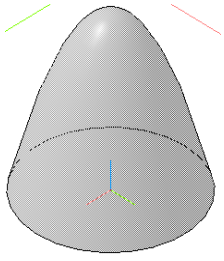
Part2

SURFACES AND AXONOMETRIC PROJECTIONS

SUBJECT 5

SOLIDS

Table 13

Polyhedrons			
Triangular prism	*Pentagonal prism*	*Quadrangular pyramid*	*Triangular pyramid*
			
Figures of revolution			
Cylinder	*Cone*	*Sphere*	*Paraboloid of revolution*
			

Answer the following question!

1. Give examples of using of surfaces (tabl. 13) in the industry?

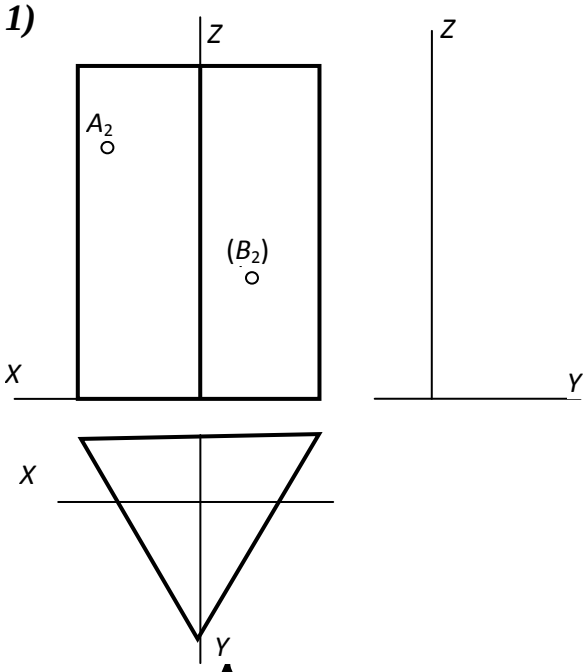
2.In which case the point belongs to the Solid?

3. How to find missing projections of a point which belongs to the surfaces (cone, sphere, pyramid)?

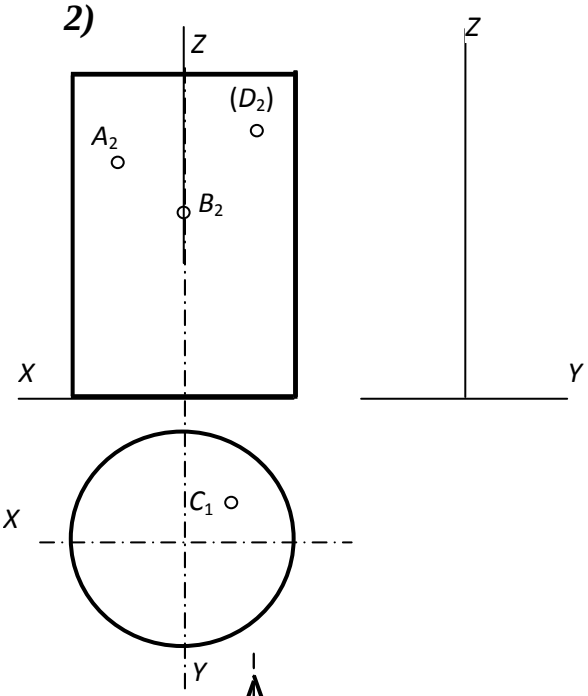
Problem 5.1

For given solids construct profile projections. Construct missing projections of a point, which belongs to the Solid.

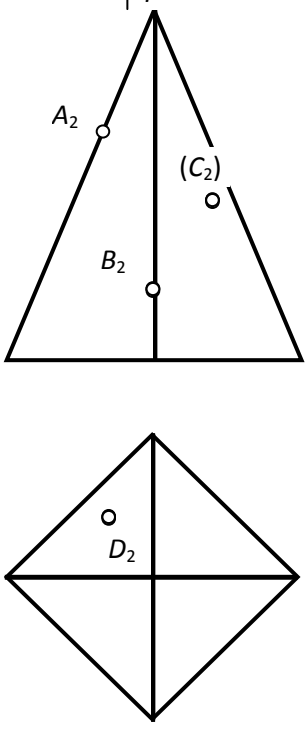
1)



2)



3)



4)

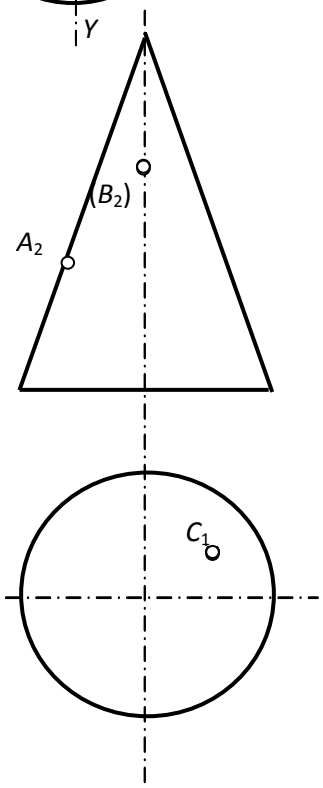
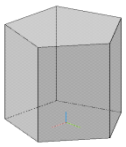
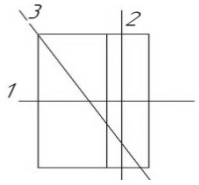
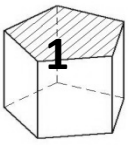
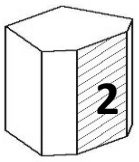
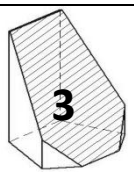
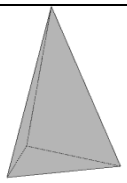
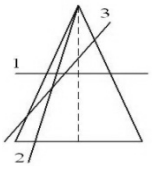
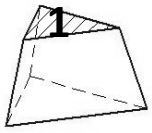
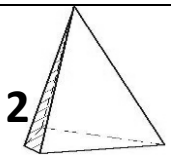
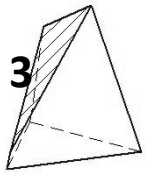
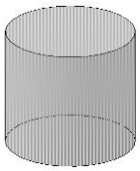
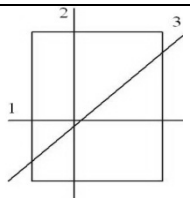
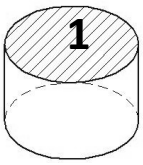
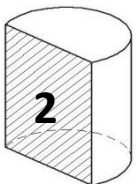
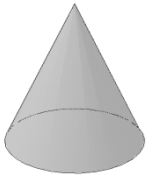
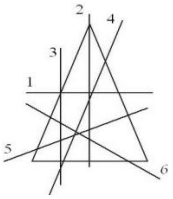
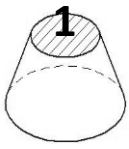
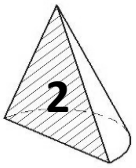
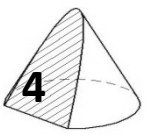
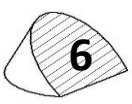


Table 14

Section of Prism				
Sections of Prism are polygons				
				
Section of Pyramid				
Sections of Pyramid are Polygons				
				
Sections of Cylinder				
Types of cylinder sections		*Circle*	*Rectangle*	*Ellipse*
				
Section of Cone				
Types of cone sections		*Circle*	*Triangle*	
				
Hyperbole	*Parabola*	*Ellipse*	*Part of ellipse*	
				

Answer the following question!

1. What figures are formed by the cross-sectional of faced surfaces? As they are based (see Table 14)?

2. Types of cylinder sections are:

1. _____

2. _____

3. _____

3. What figure is formed in the sections of sphere? _____.

4. What direction should have a cutting plane of the next cone section:

ellipse _____;

part of ellipse _____;

parabola _____;

hyperbola _____;

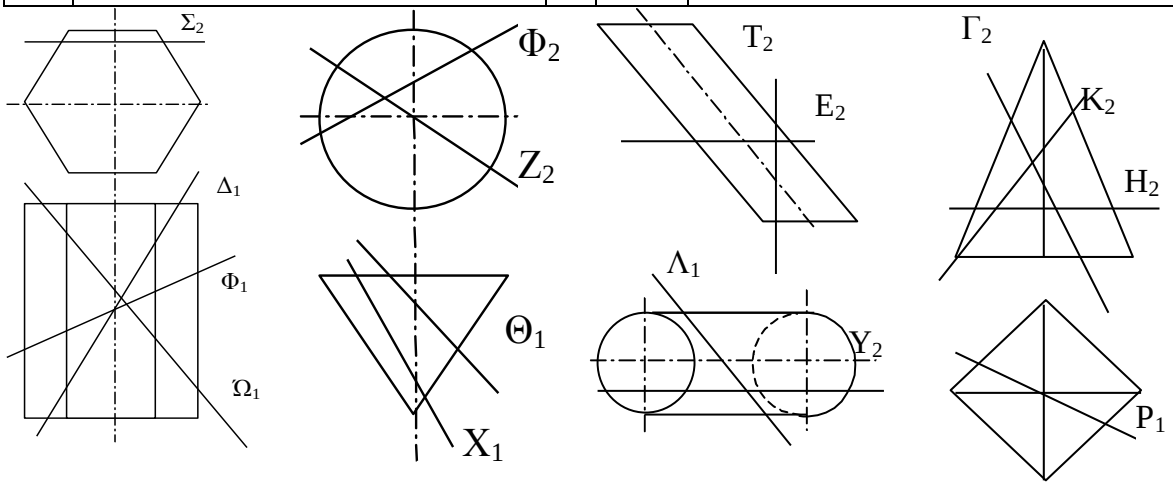
triangle _____;

circle_____?

Speaking exercise 5.1

Determine the Form of the Each Solids sections.

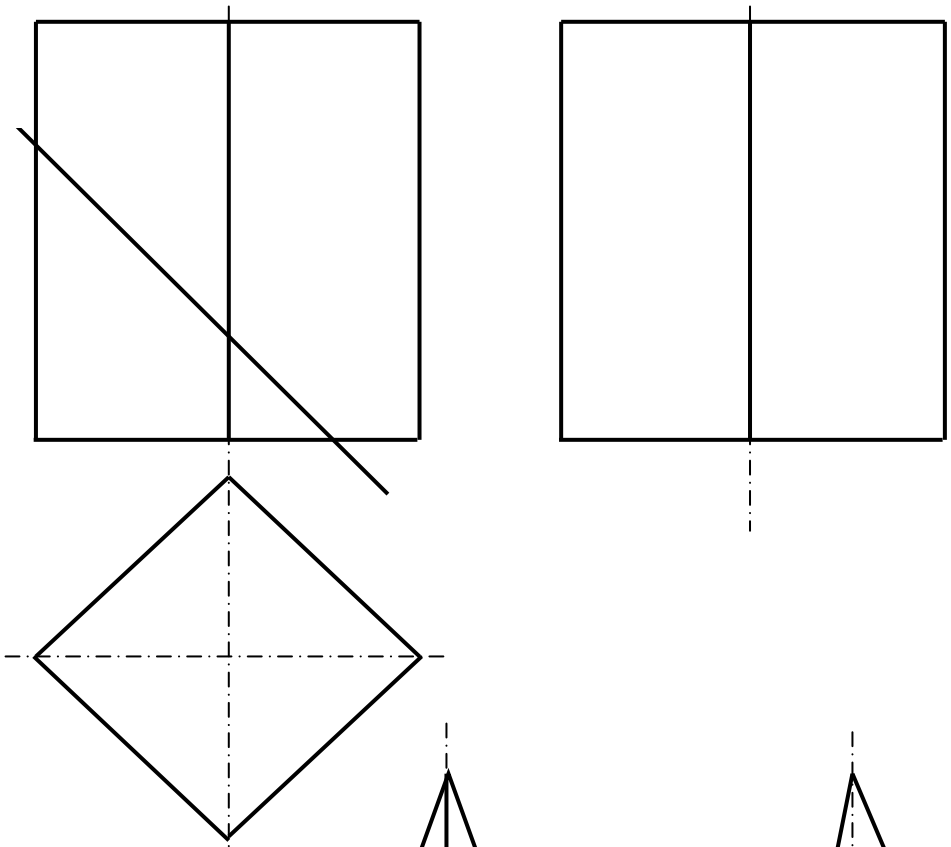
1	circle		9	isosceles triangle	
2	ellipse		10	octagon	
3	square		11	heptagon	
4	rectangle		12	equilateral triangle	
5	part of the ellipse (more than half)		13	part of the ellipse (less than half)	
6	quadrangle		14	parallelogram	
7	pentagon		15	parabola	
8	hexagon		16	hyperbole	



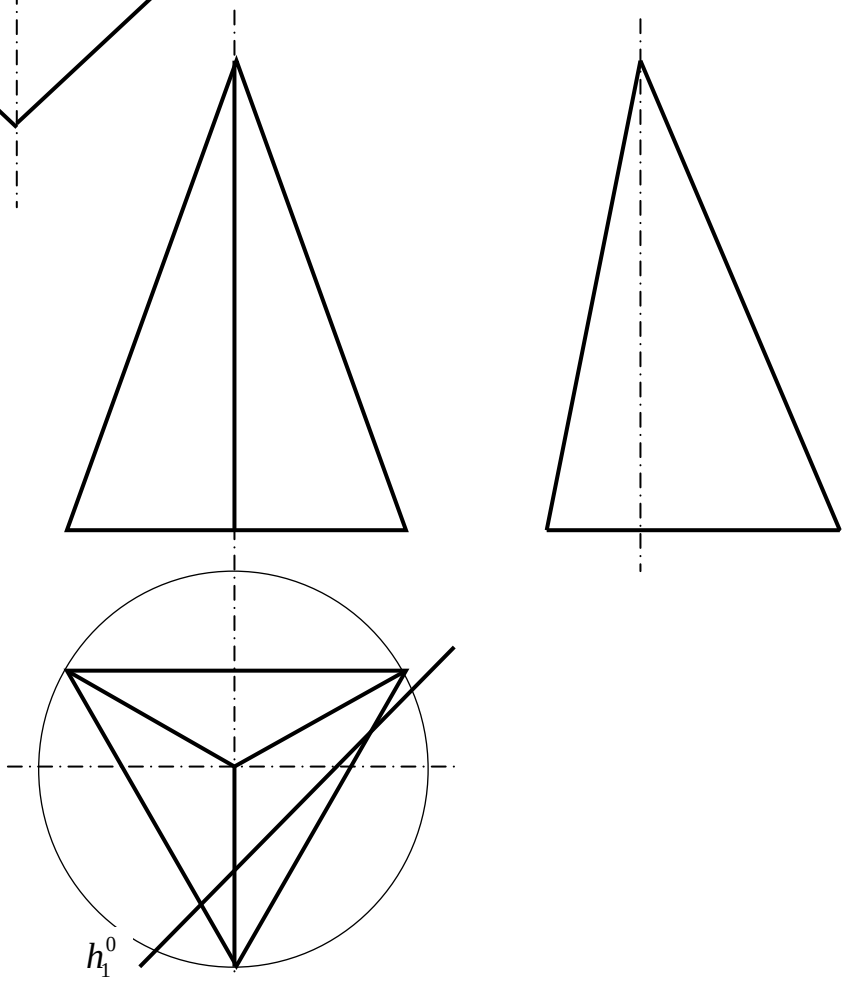
Task 5.2

Construct three projections and find the true size of the sections of the given geometrical bodies by the projecting planes.

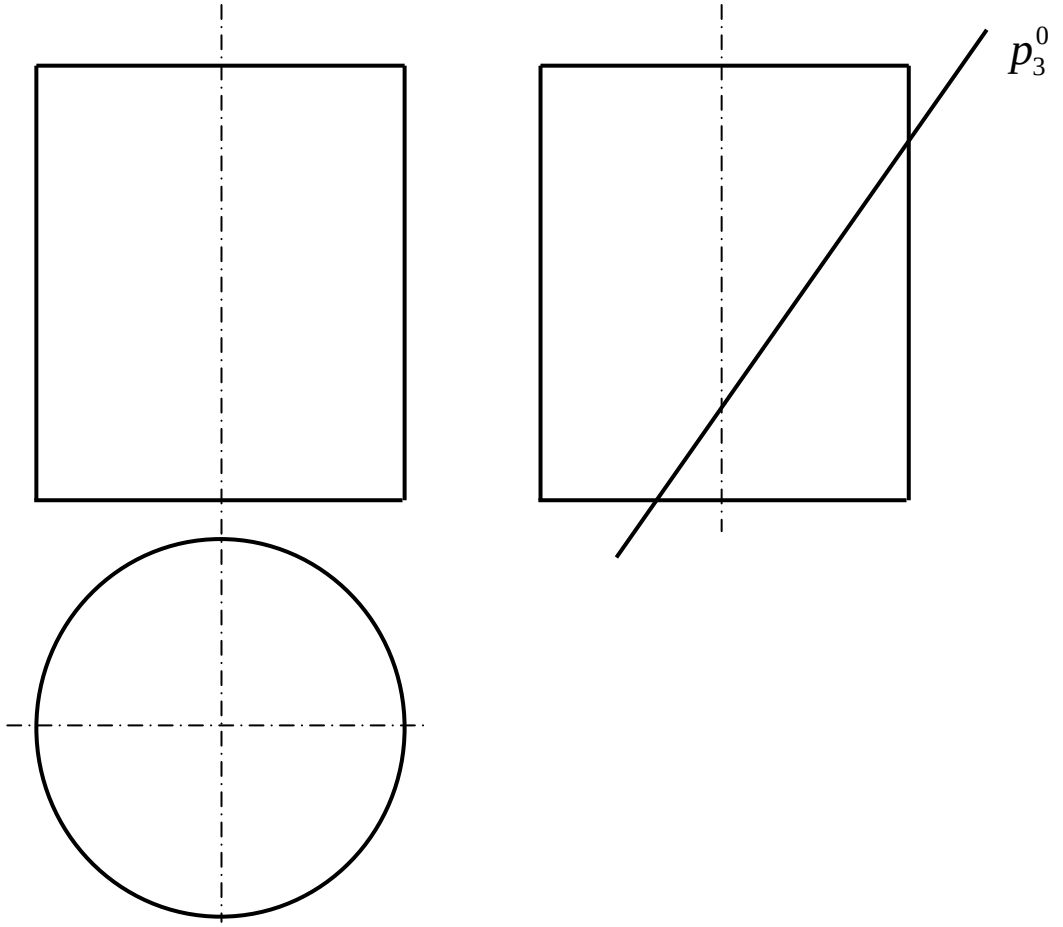
1)



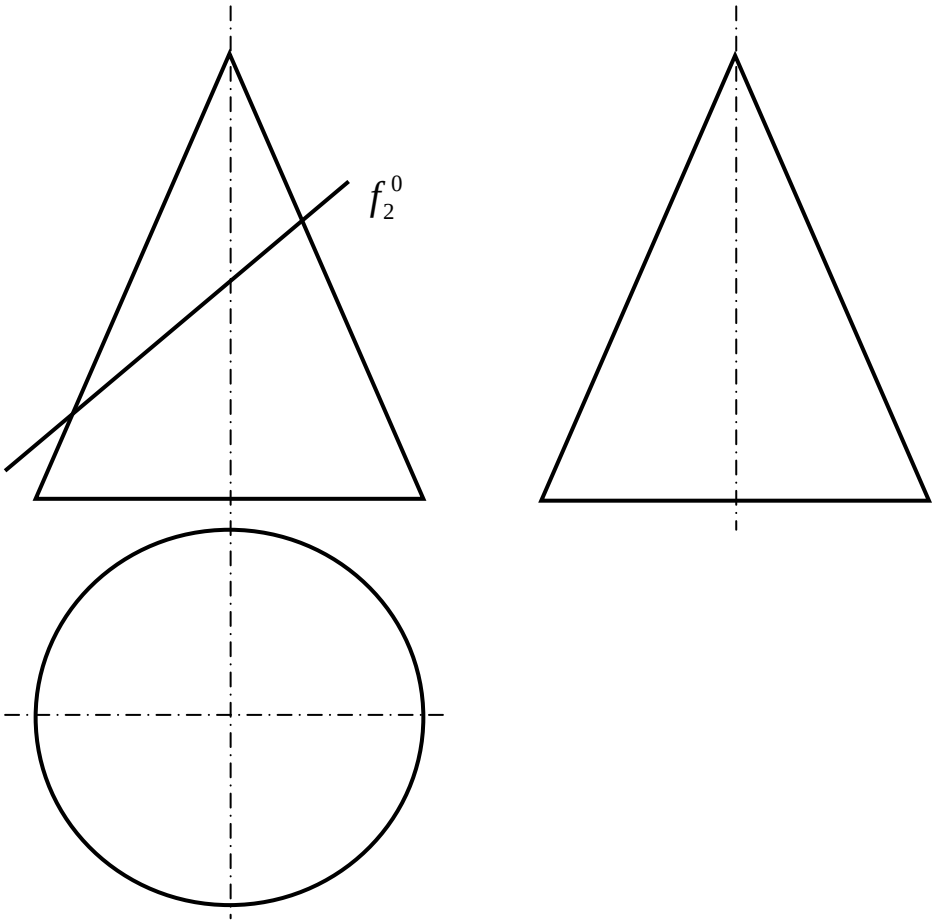
2)



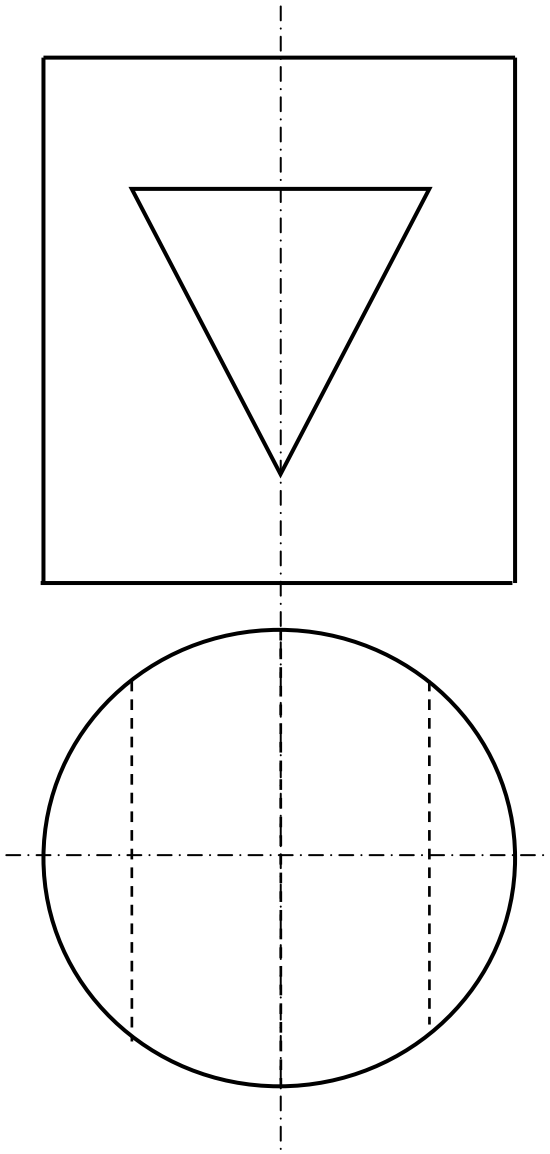
3)



4)



Task 5.3 Construct three projections and find the true size of the section.



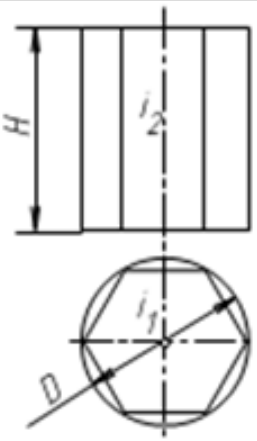
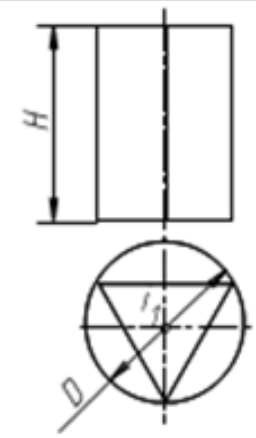
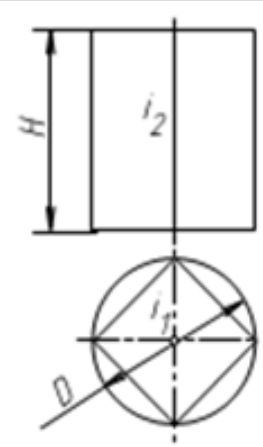
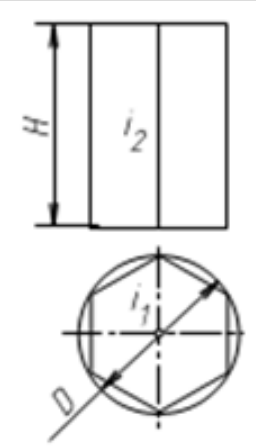
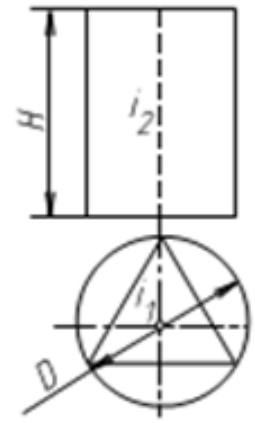
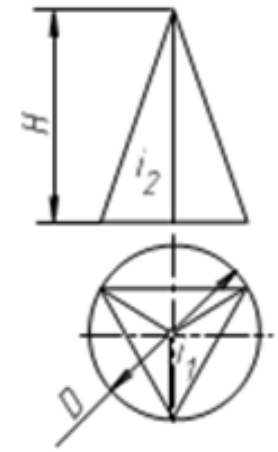
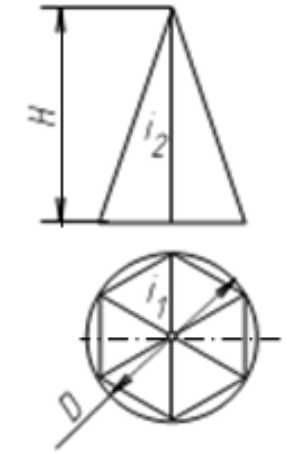
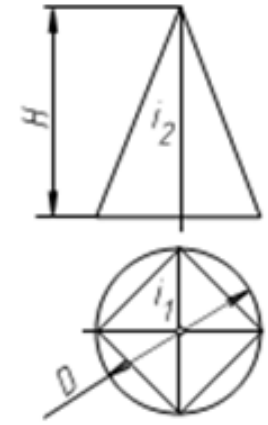
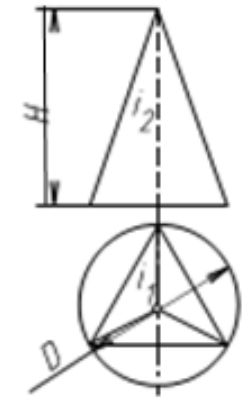
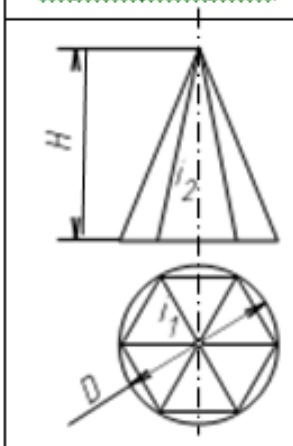
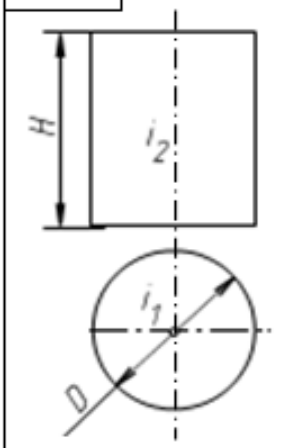
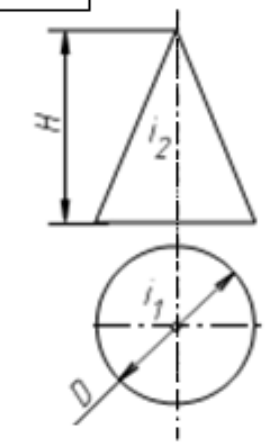
HOMETASK

Construct a four Solids on the two Formats A3 . Use all parameters from Table 15, 16. On each geometrical solid a student gets a section plane, construct projection of section and its true size. The example of the task 4 and 5 « SOLIDS » is presented in Annex 4.

Table 15

Variant	Prism		Pyramid		Cylinder		Cone		Variant	Prism		Pyramid		Cylinder		Cone	
	D	H	D	H	D	H	D	H		D	H	D	H	D	H	D	H
1	90	100	95	115	80	105	80	115	**21**	95	115	90	100	80	115	80	105
2	95	115	90	110	80	95	90	110	**22**	90	110	95	115	90	110	80	95
3	80	100	70	105	85	100	90	105	**23**	70	105	80	100	90	105	85	100
4	85	110	75	115	70	110	90	115	**24**	75	115	85	110	90	115	70	110
5	90	100	95	85	85	105	95	85	**25**	95	85	90	100	95	85	85	105
6	95	115	90	95	85	90	95	95	**26**	90	95	95	115	95	95	85	90
7	75	95	75	95	75	100	80	95	**27**	75	95	75	95	80	95	75	100
8	80	95	80	95	75	105	90	95	**28**	80	95	80	95	90	95	75	105
9	90	105	90	85	80	90	95	85	**29**	90	85	90	105	95	85	80	90
10	80	90	60	85	75	110	90	85	**30**	60	85	80	90	90	85	75	110
11	95	100	65	85	85	96	90	85	**31**	65	85	95	100	90	85	85	96
12	85	105	60	85	80	80	85	85	**32**	60	85	85	105	85	85	80	80
13	90	90	60	95	80	90	90	95	**33**	60	95	90	90	90	95	80	90
14	85	110	60	90	90	100	90	90	**34**	60	90	85	110	90	90	90	100
15	90	115	60	95	80	115	75	95	**35**	60	95	90	115	75	95	80	115
16	95	115	55	80	60	95	60	80	**36**	55	80	95	115	60	80	60	95
17	80	100	55	80	60	95	65	80	**37**	55	80	80	100	65	80	60	95
18	75	95	60	85	55	80	55	85	**38**	60	85	75	95	55	85	55	80
19	80	95	60	80	55	80	65	80	**39**	60	80	80	95	65	80	55	80
20	95	100	95	115	60	85	55	115	**40**	95	115	95	100	55	115	60	85

Table 16

1,6,11,16,21,26,31,36	2,7,12,17,22,27,32,37	3,8,13,18,23,28,33,38	4,9,14,19,24,29,34,39
			
5,10,15,20,25,30,35,40	1,6,11,16,21,26,31,36	2,7,12,17,22,27,32,37	3,8,13,18,23,28,33,38
			
4,9,14,19,24,29,34,39	5,10,15,20,25,30,35,40	1-40	1-40
			

SUBJECT 6

AXONOMETRIC PROJECTION

6.1 REGULAR ISOMETRIC

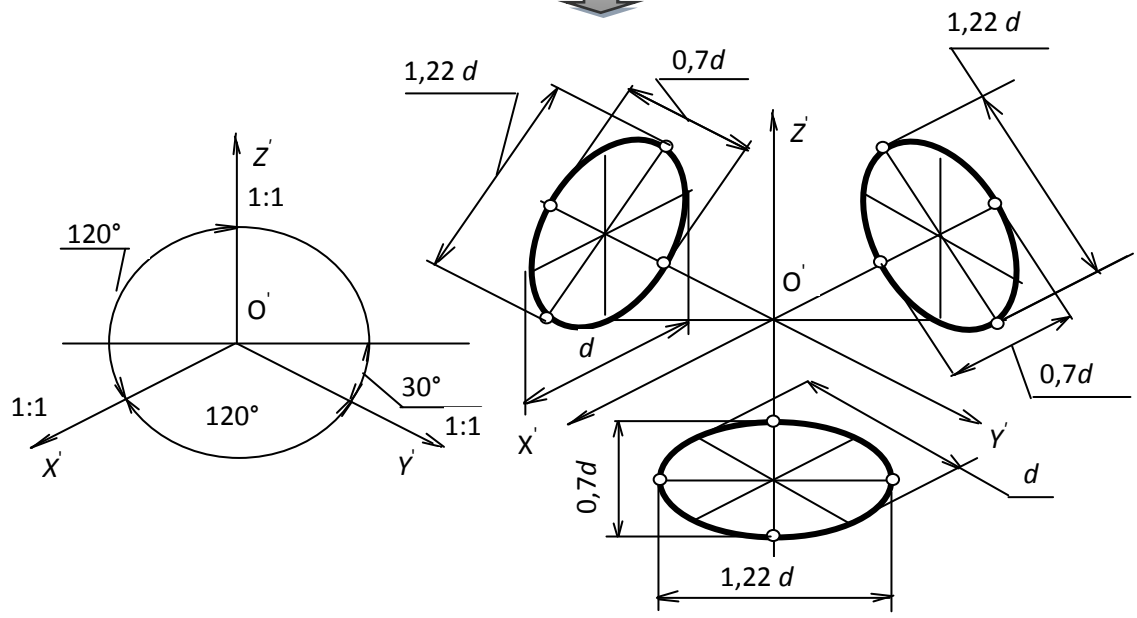
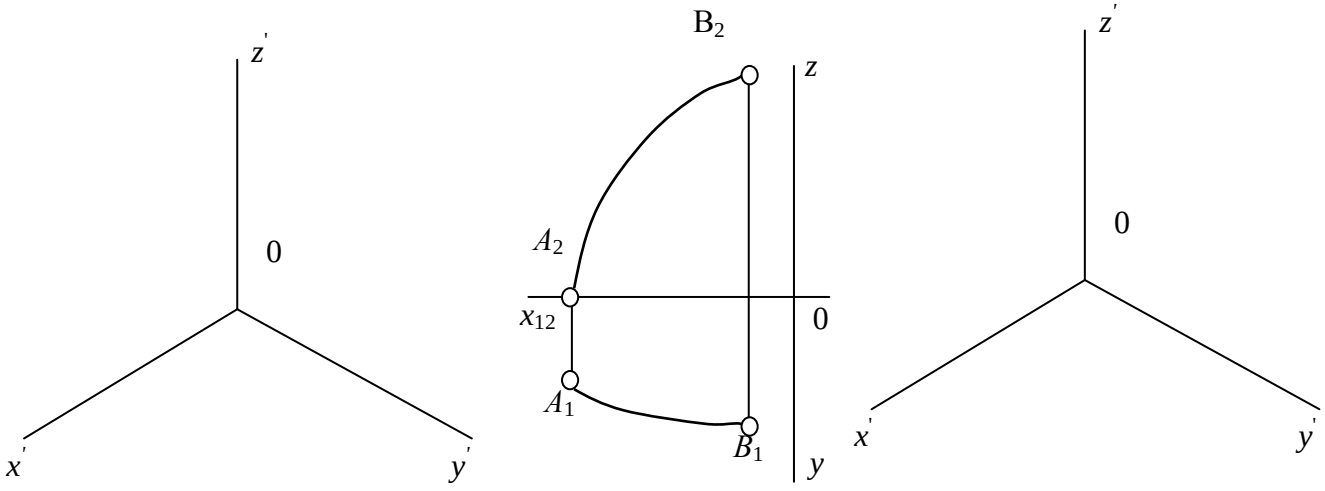


Fig. 6.1. Rectangular isometric

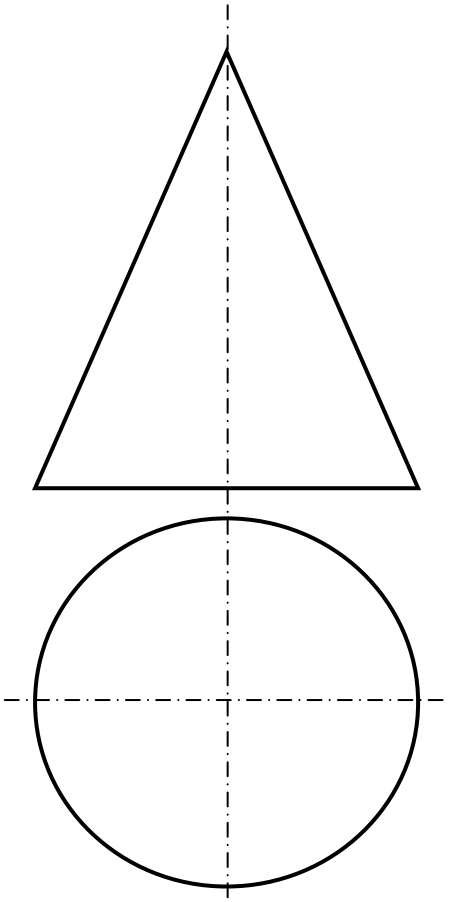
Problem 6.1 Construct regular isometric projections of the point *C* (20, 10, 30) and the curve *AB*.

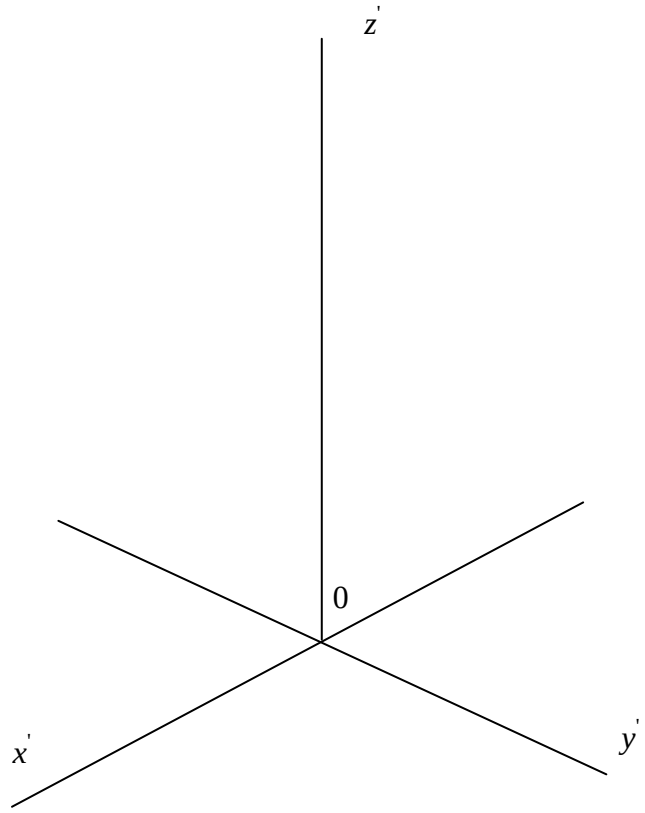


Problem 6.2

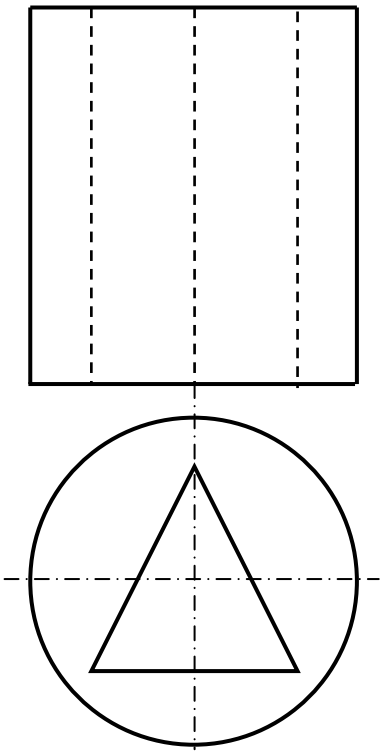
Construct a regular isometrics of the cone and the cylinder with the ¼ of.

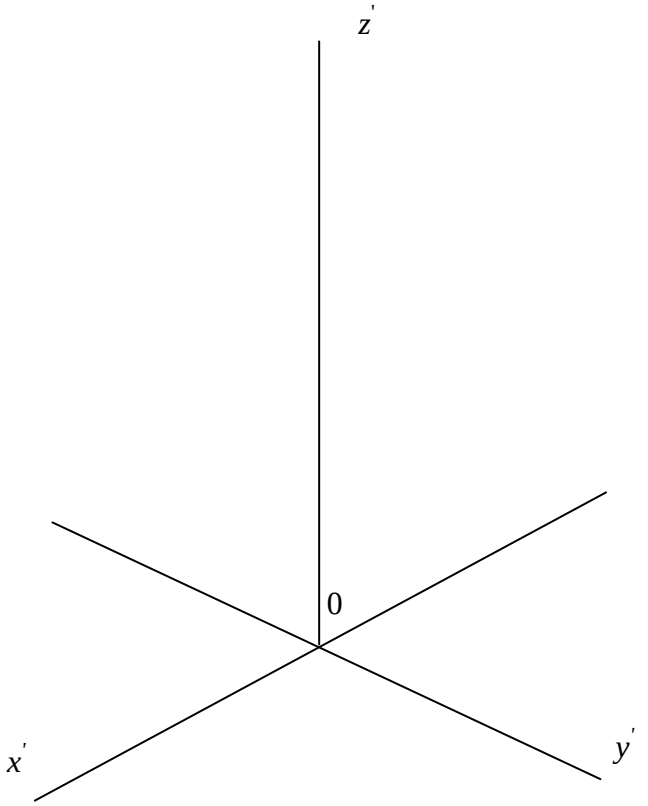
1)





2)





6.2 RIGHTANGULAR DIMETRIC

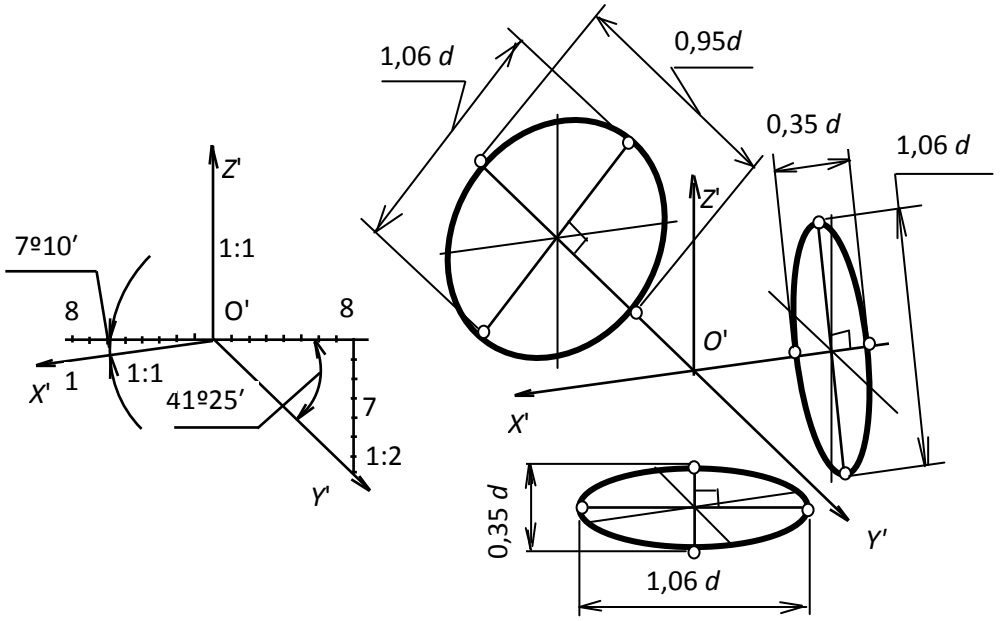
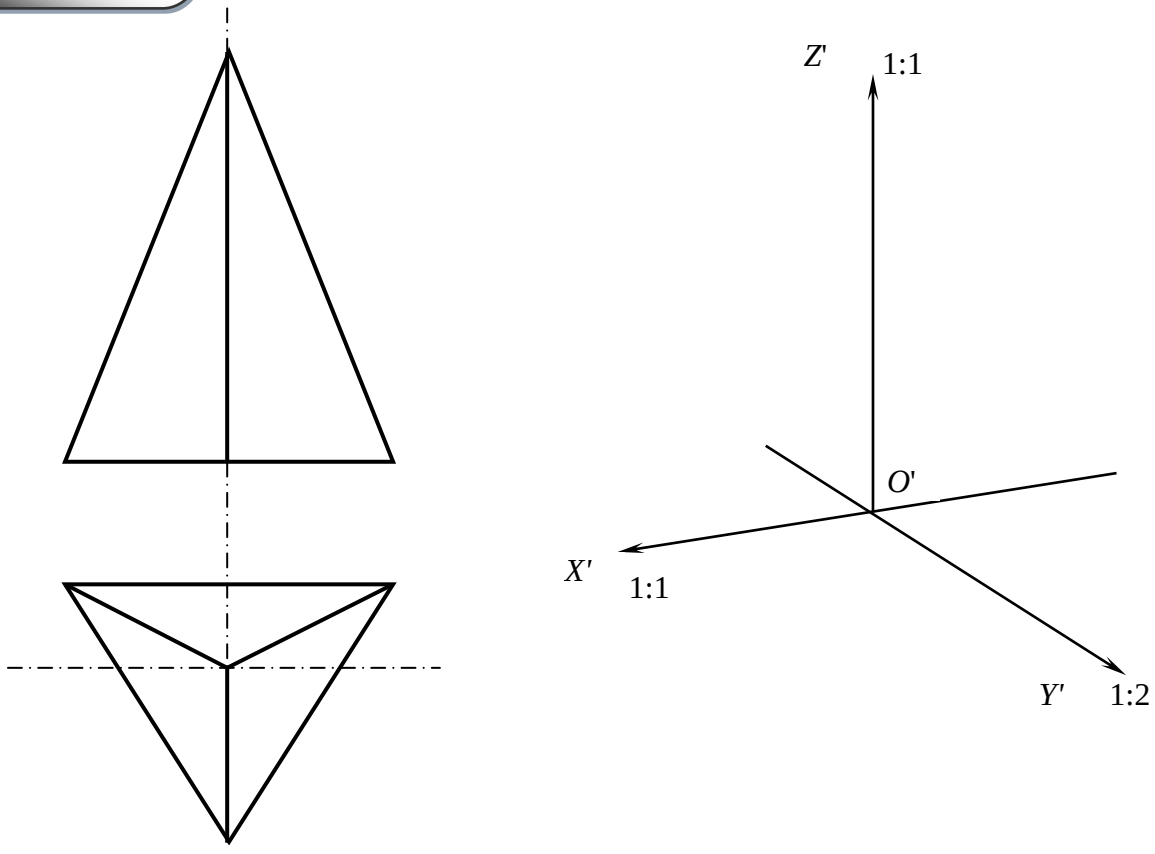


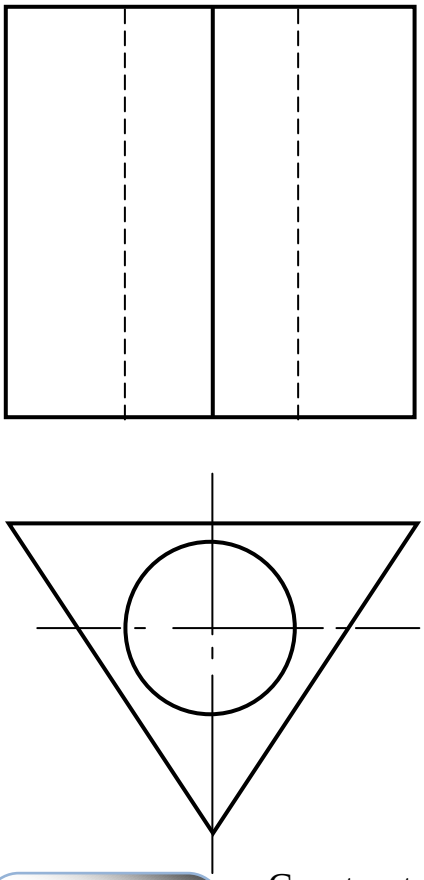
Fig. 5.2. Rectangular dimetric

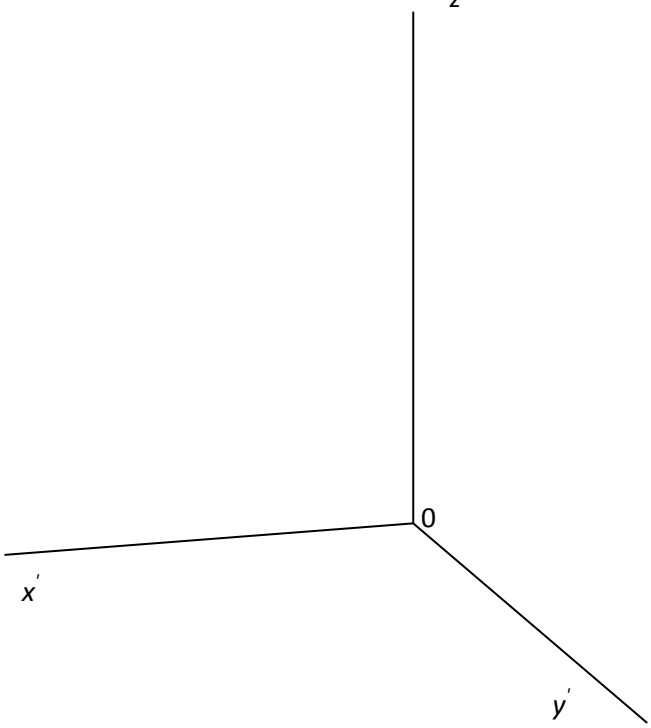
Problem 6.3 Construct rectangular dimetric projection of the pyramid with the ¼ of.



Problem 6.4

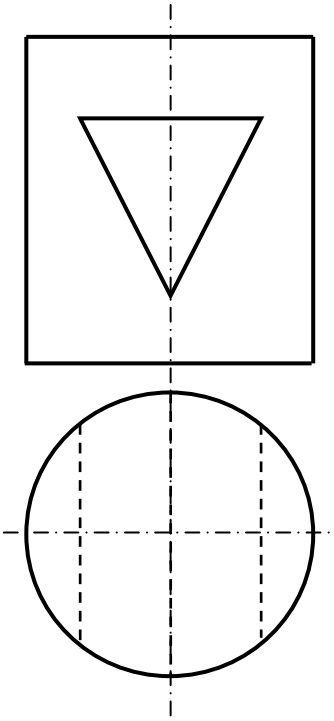
Construct a rectangular dimetric projection of the prism with a through cylindrical hole with removal ¼ of.

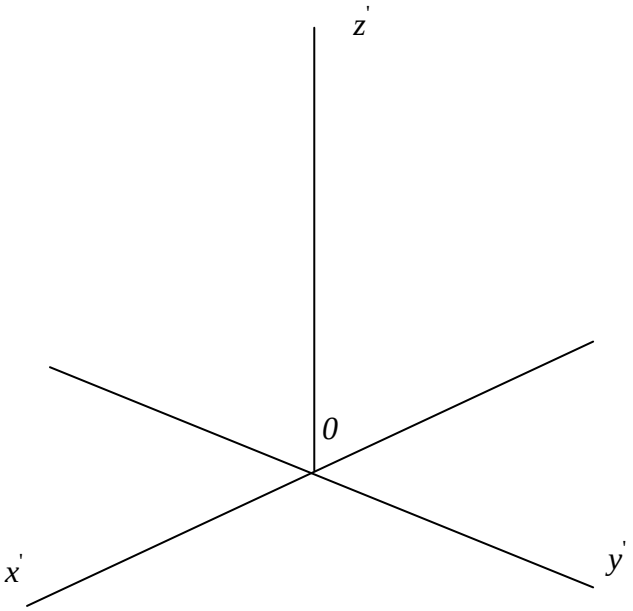




Problem 6.5

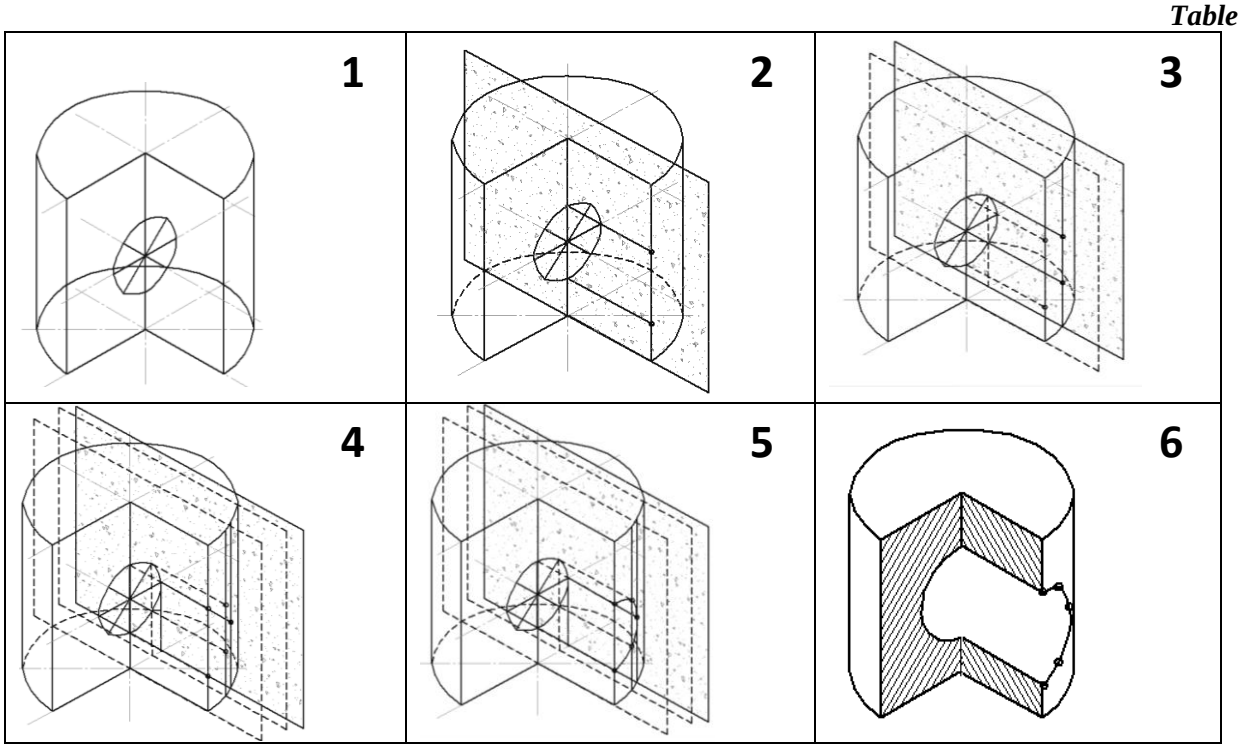
Construct a rightangular isometric projection of a cylinder with through prismatic hole, using method of cutting planes (Table 17, 18).





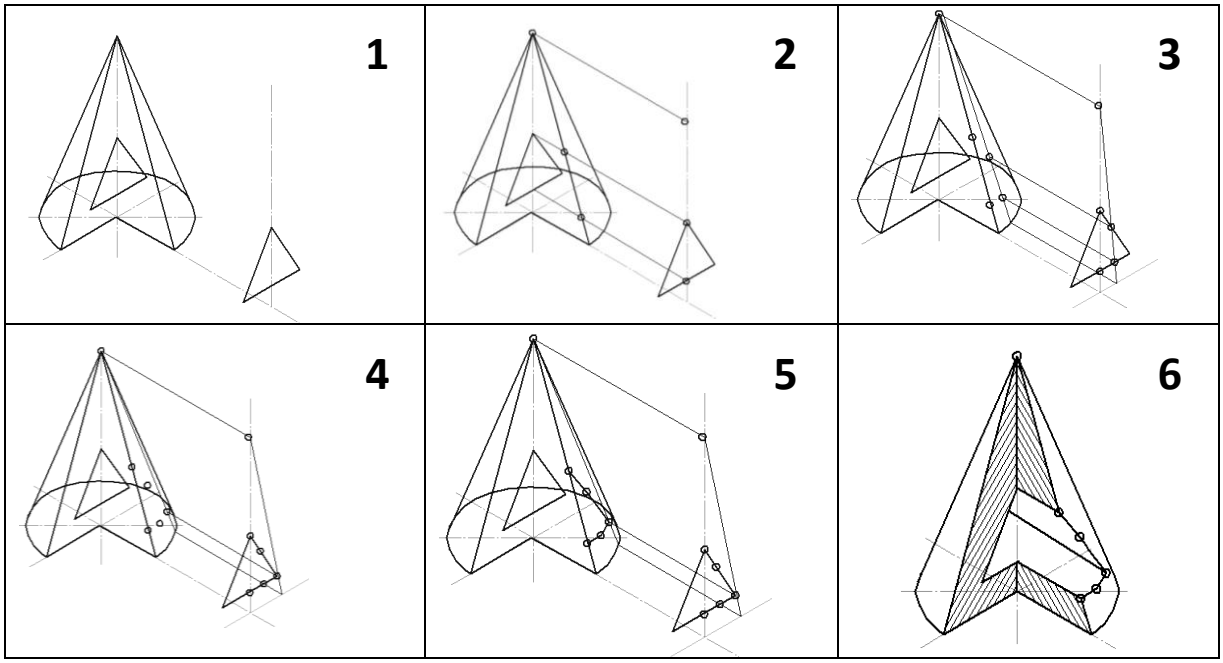
Axonometric of the cylinder with a cylindrical hole with the method of cutting planes. Succession of constructions.

Table 17



Constructions axonometric of the cone with prismatic hole by the method of cutting planes

Table 18



HOMETASK

Construct an Axonometric of the Solid on the Formats A4. Use all parameters from Table 15, 16. The example of the task 6 «AXONOMETRIC DRAWING» is presented in Annex 5.

PART 3

PROJECTIONS WITH ELEVATIONS

SUBJECT 7

POINTS

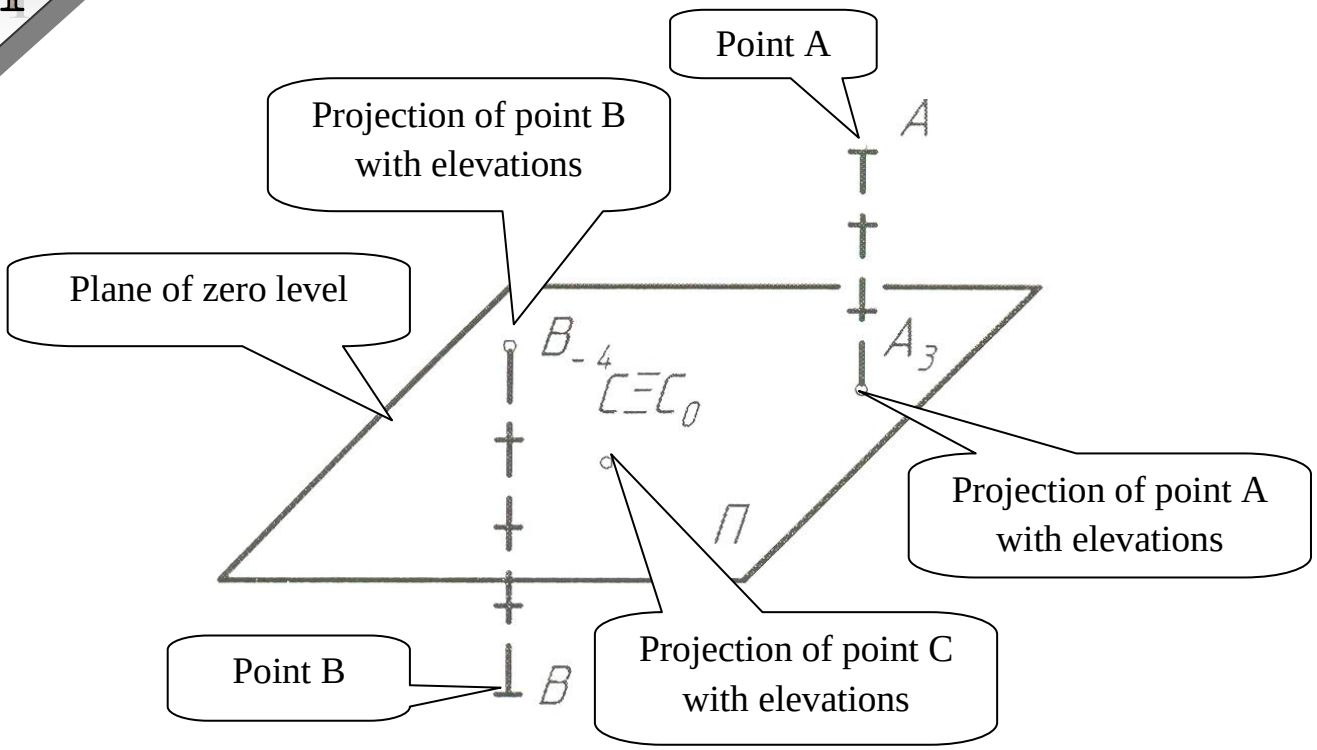


Fig. 7.1. Projections of points with elevations

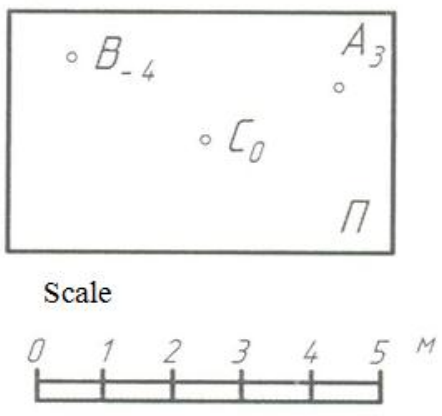


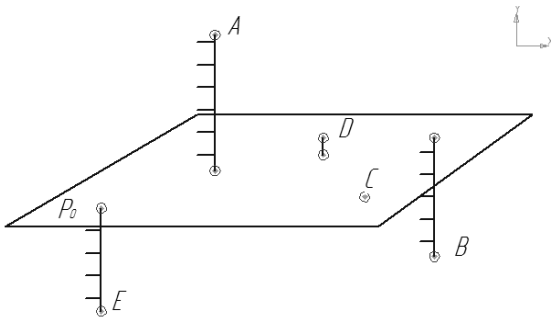
Fig. 7.2. Orthographic drowning of projections with elevations

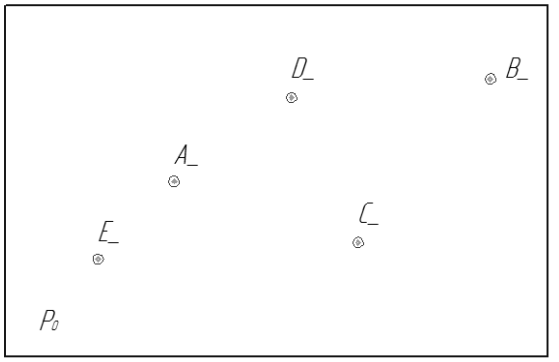
The idea of this method: The Point is projected on the Plane π_0 (fig. 7.1, 7.2). Index of the Point shows it's elevation. Elevation is the Height (dept) of the Point with respect to zero level Plane.

Origin of idea of the "Projections with Elevations" method refer to the Middle Ages. Already then many people, using cards with indications of sea depths, were able to represent a point by means of its projection and a mark. However the method received theoretical justification only in the 19th century, thanks to the French military engineer – the captain Nuaza (1823).

Problem 7.1

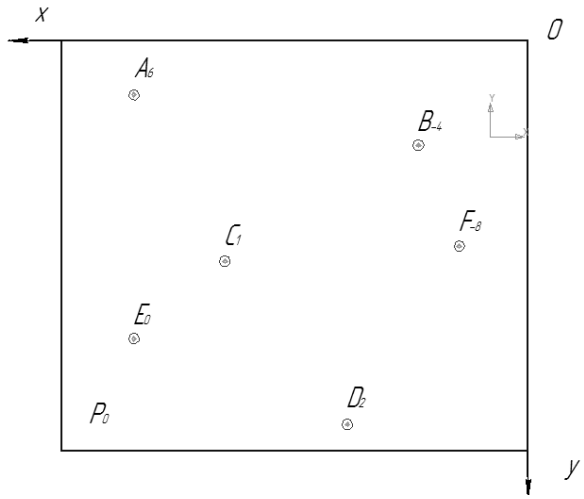
For given points build projections of these points with elevations.

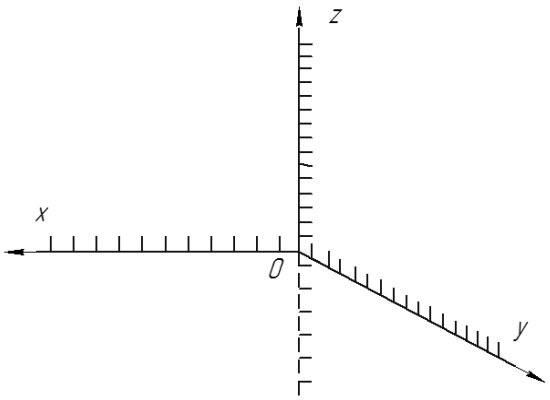




Problem 7.2

For the given projections with elevations of the points construct points in a pictorial view.





SUBJECT 8

LINES

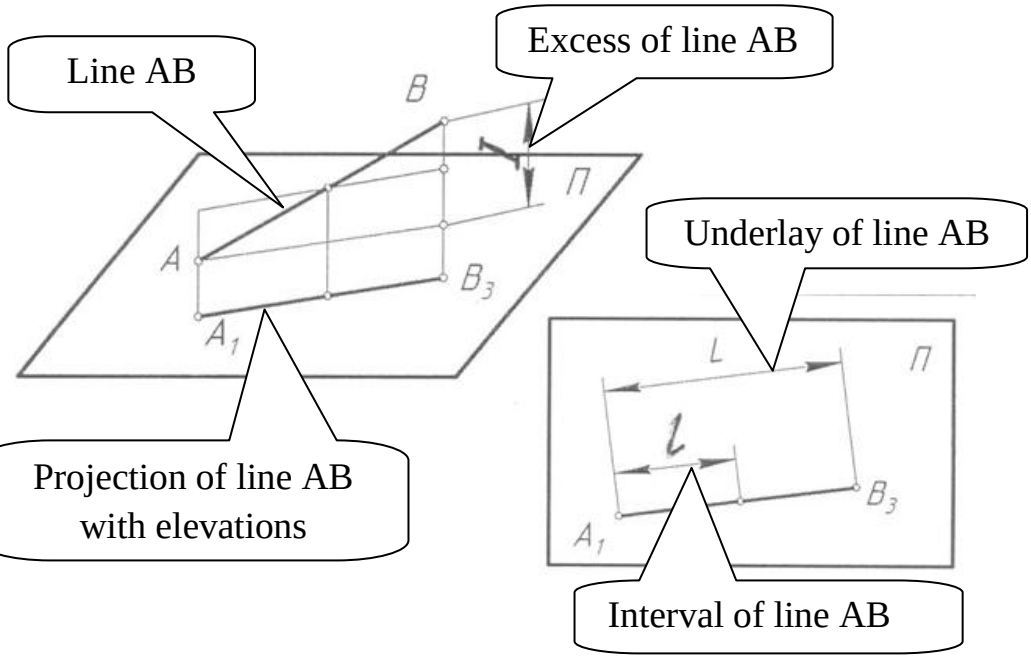


Fig. 8.1. Projections of line with elevations

STRAIGHT LINE GRADUATION

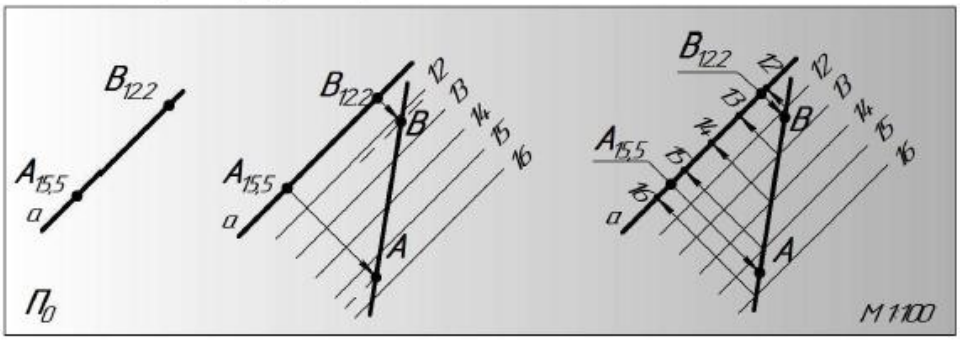


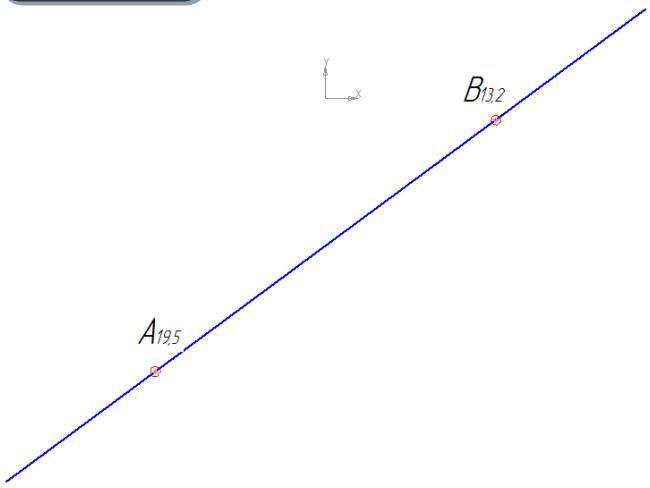
Fig. 8.2. Straight line graduation

A line, in general position to the projection plane, is repre- sented with its horizontal proje- ction and with the points on it that have integer ele- vations (Fig.8.1.).

Construct parallel straight lines to graded line with distance from each other, for example, 1 cm. and call them level lines with integer marks 12, 13, 14 … Make perpendiculars from the main points $A_{15,5}$ and $B_{12,2}$ to the level lines and find The Points A and B. Connect them into straight line AB (Fig. 8.2).

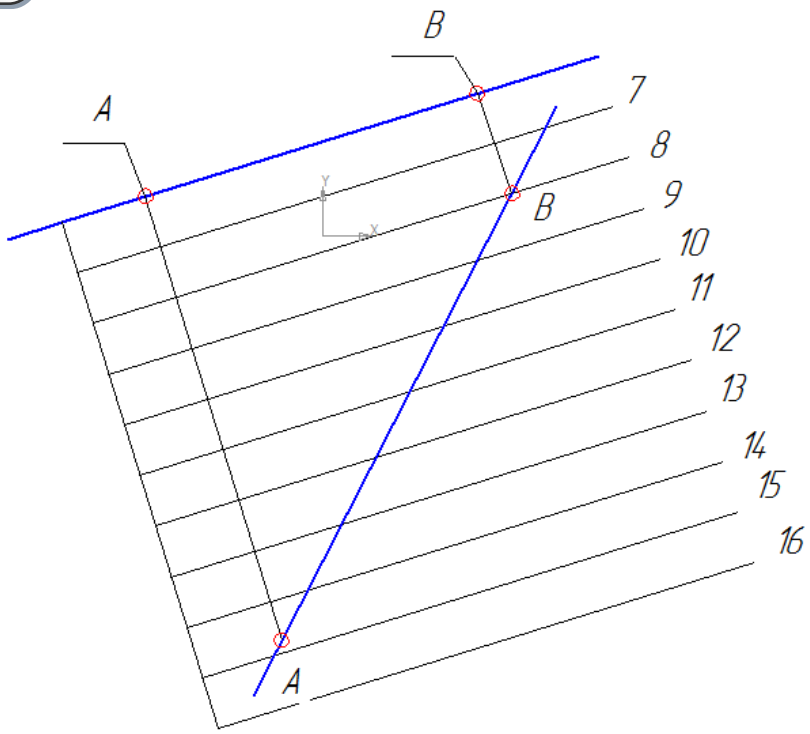
Problem 8.1

For given line build straight line graduation



Problem 8.2

For given line build Straight line graduation



SUBJECT 9

PLANES

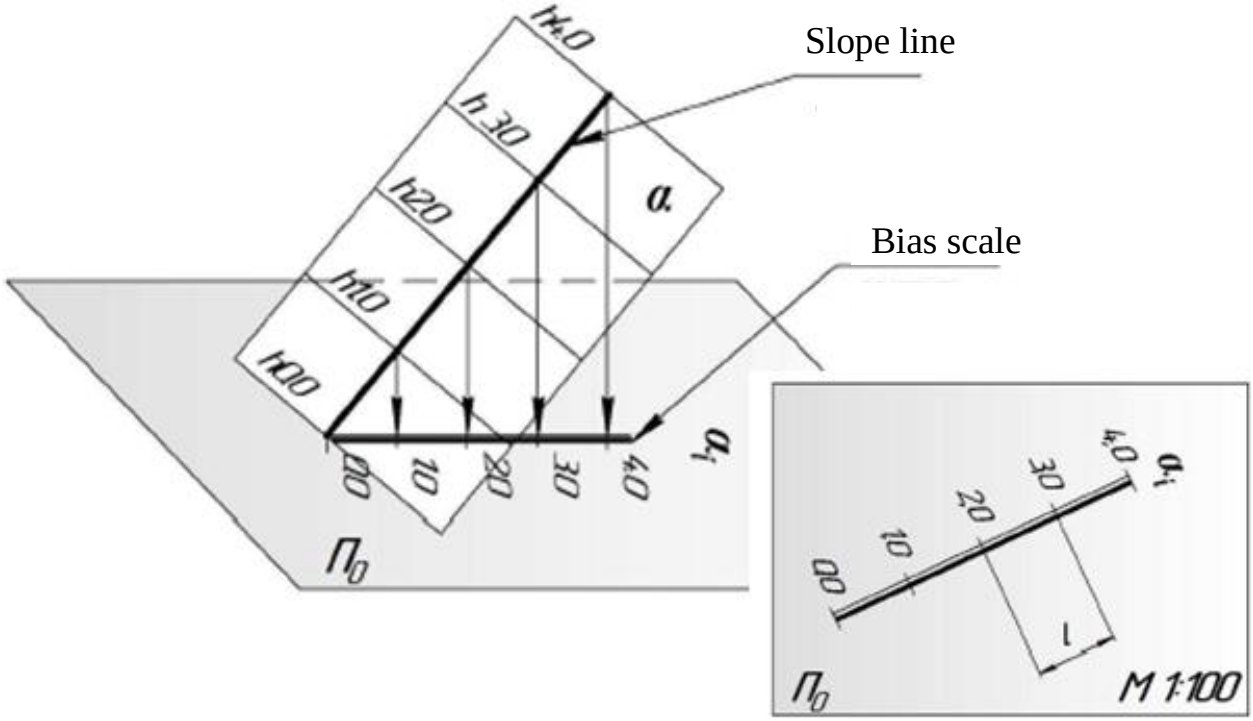


Fig. 9.1. Plane graduation

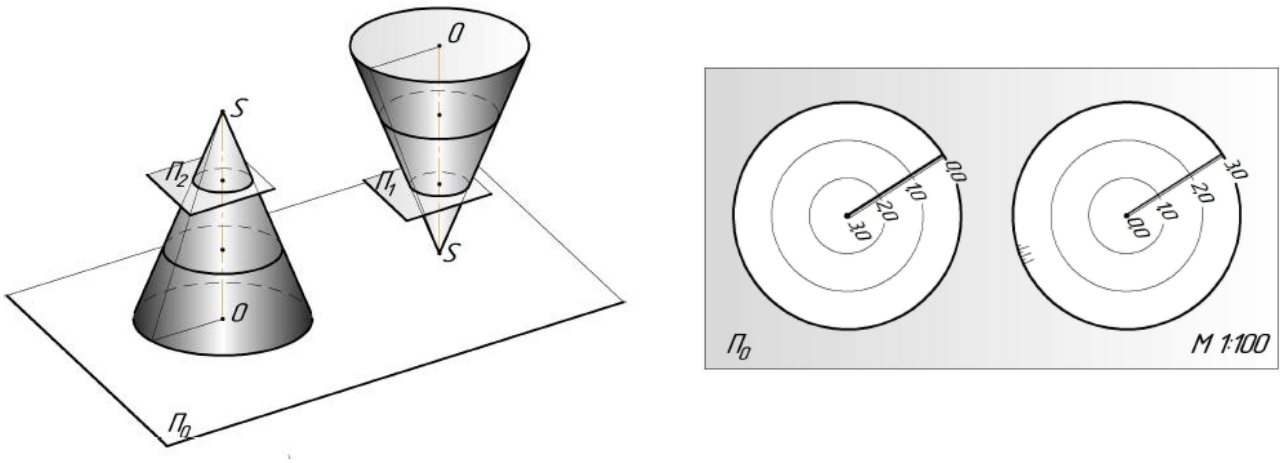


Figure 9.2. Graduation of surface of revolution

SUBJECT 10 PROJECTIONS OF TOPOGRAPHICAL SURFACES

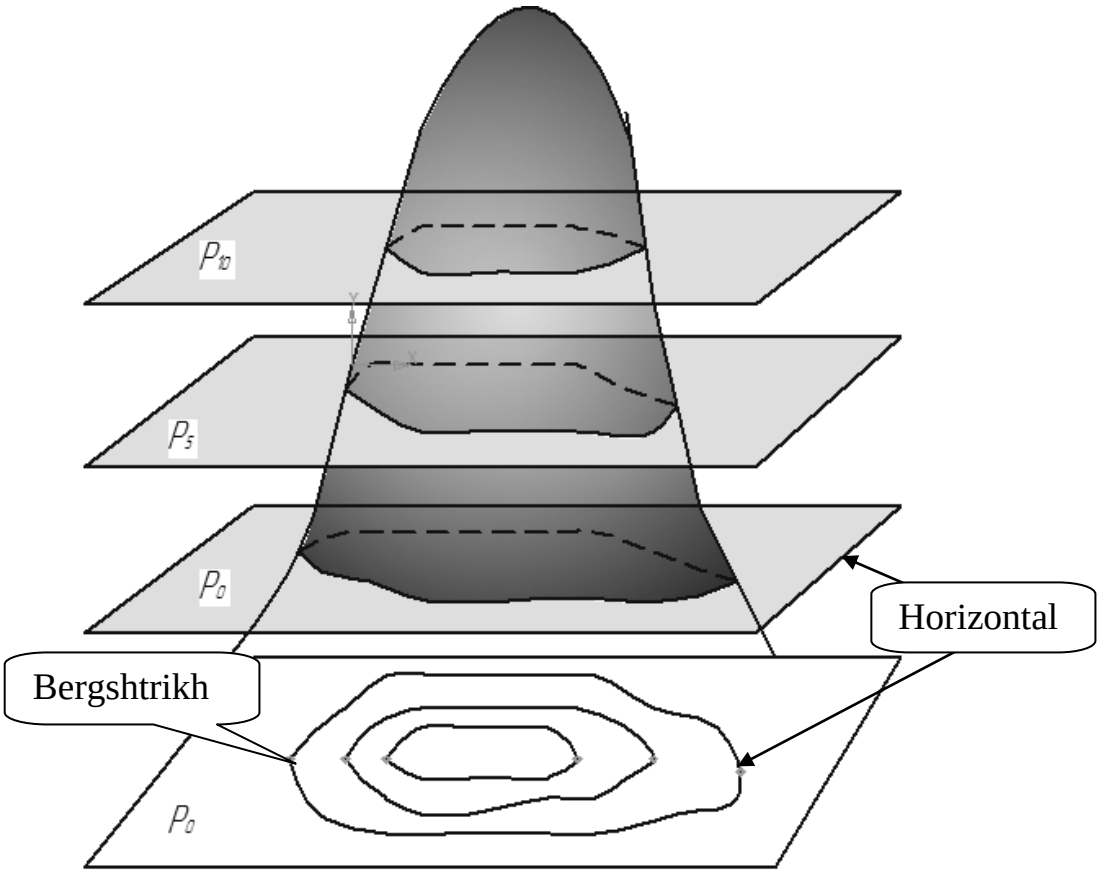


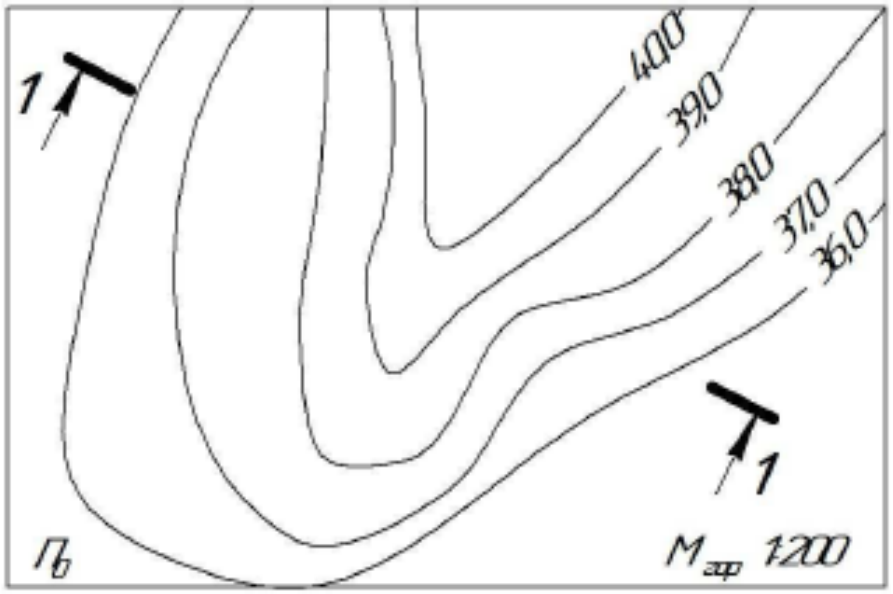
Fig.10.1. Projections of topographical surfaces

Contour lines are lines on map that connect points of equal elevation.

Contour interval is the difference in elevation between two side-by-side contour lines.

Index contours are contour lines marked with their elevations (Bershtrikh).

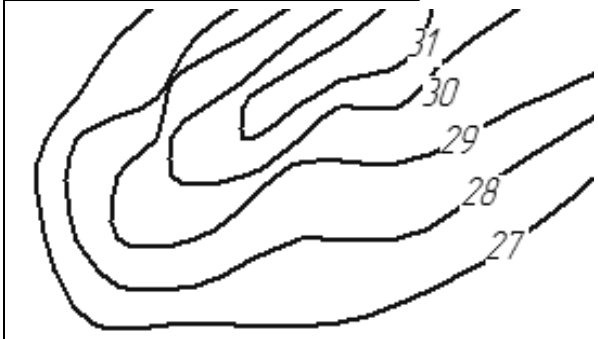
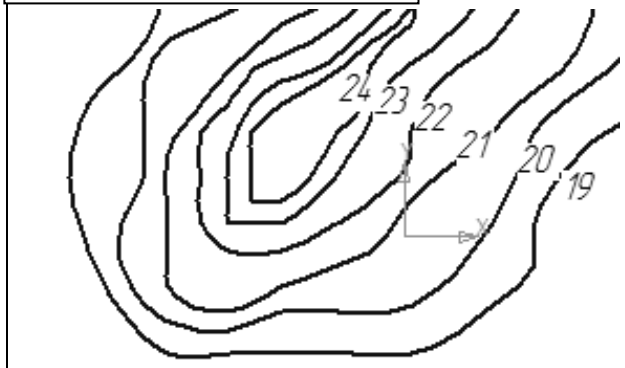
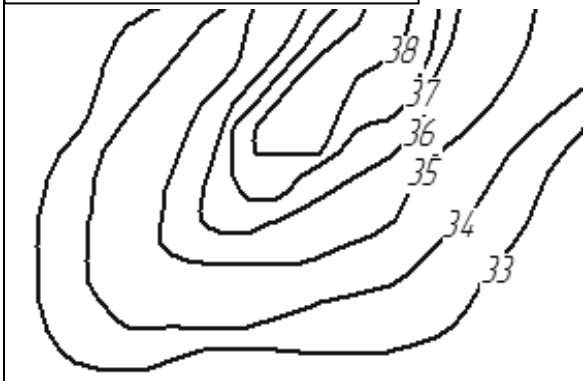
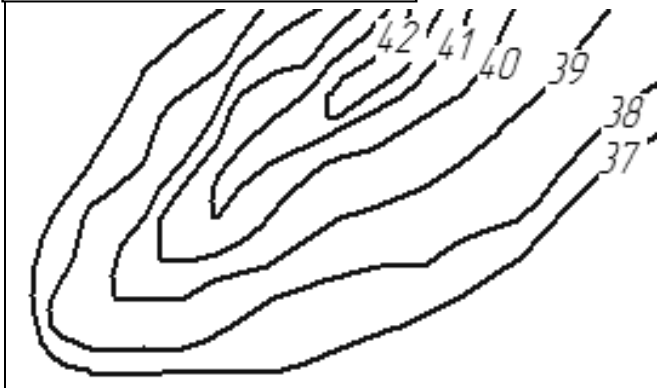
Problem10.1 Construct the Profile of a topographical Surface. Use example.



HOMETASK

Construct the Projection of Topographical surfaces on the Formats A4. Use all parameters from Table 19. The example of the task 7 «PROJECTIONS OF TOPOGRAPHICAL SURFACES» is presented in Annex 6.

Table 19

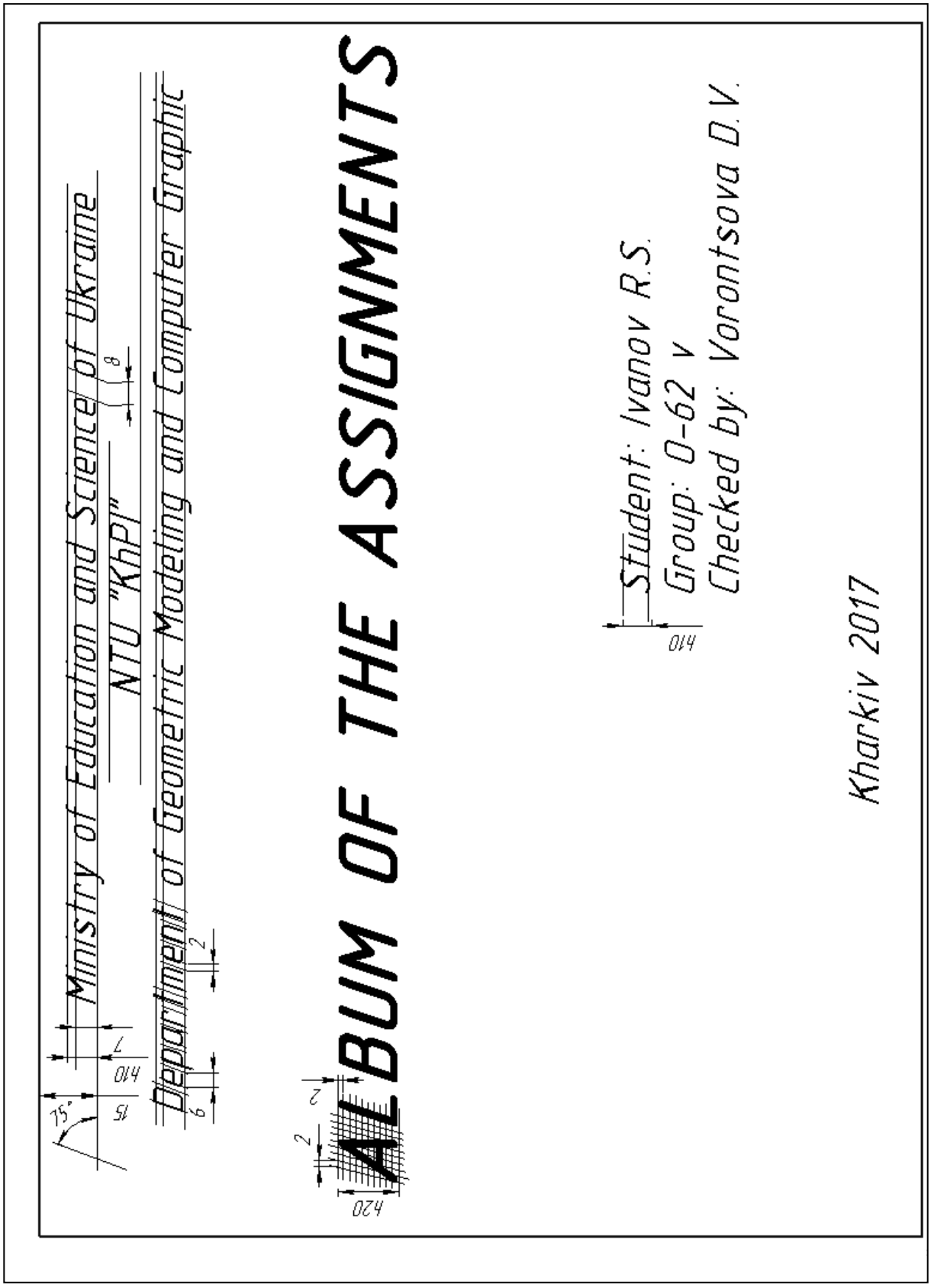
1,7,13,19,25,31,37 	2,8,14,20,26,32,38 
3,9,15,21,27,33,39 	4,10,16,22,28,34,40 
5,11,17,23,29,35 	6,12,18,24,30,36 

Answers to the test questions									
№	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
Answers	***I***	***8***	Π_3 Π_1	***BC,GH***	***GH***	***1***	***M***	$\sum$	$\triangle$ ***CDE***

ANNEXES

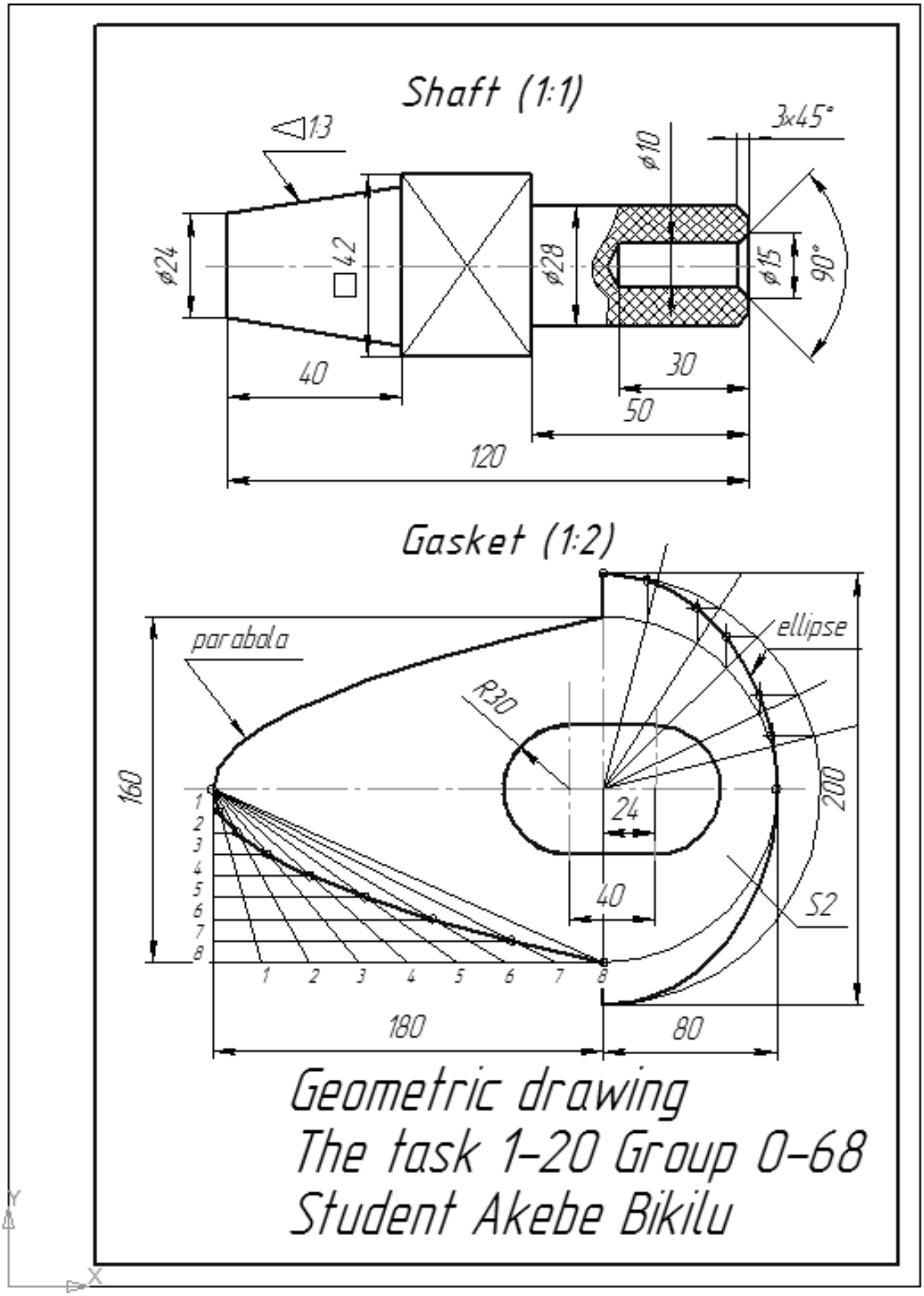
ANNEX 1

The example of the Title Page.



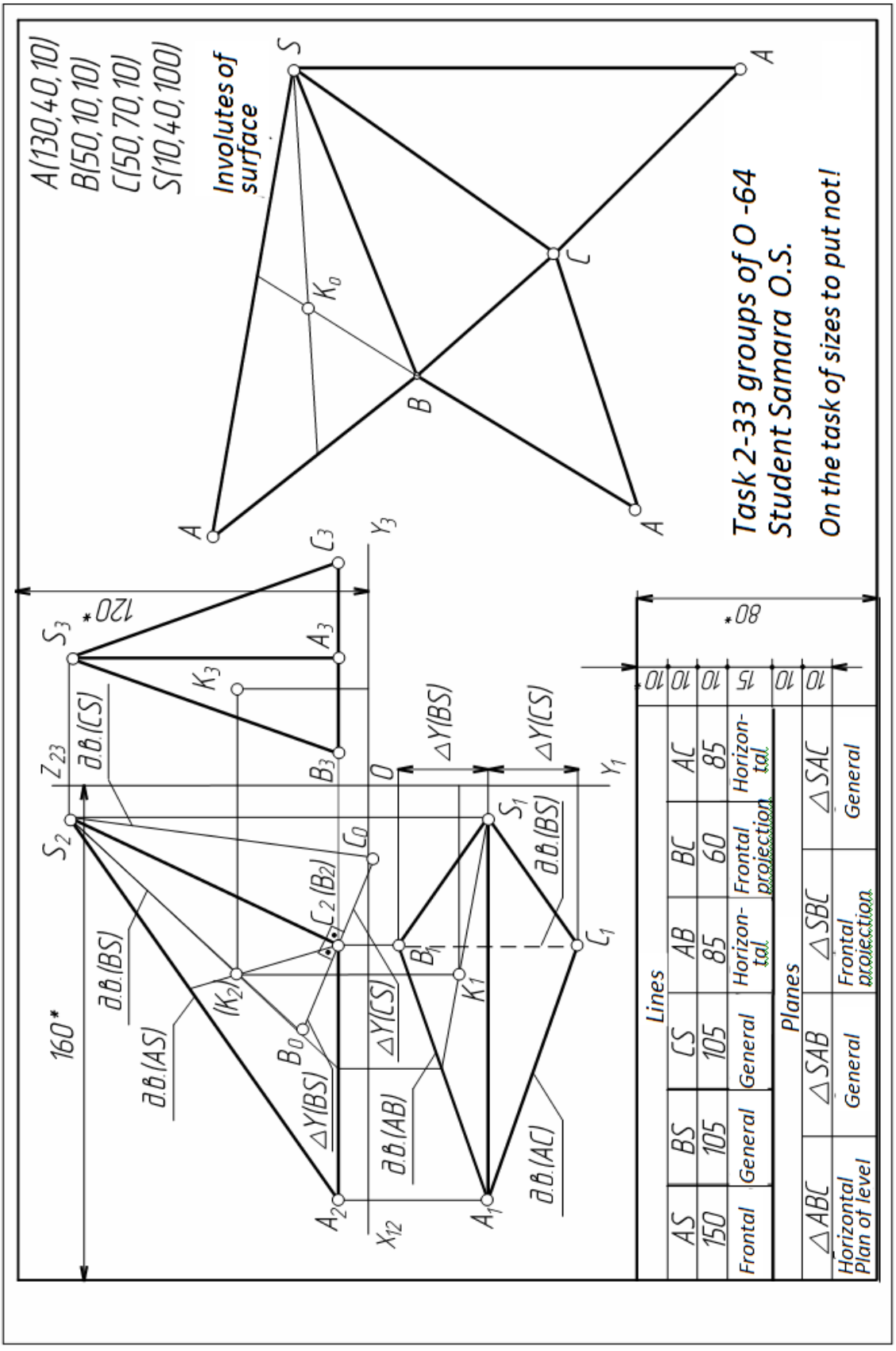
ANNEX 2

The Example of the Shaft and The Gasket.



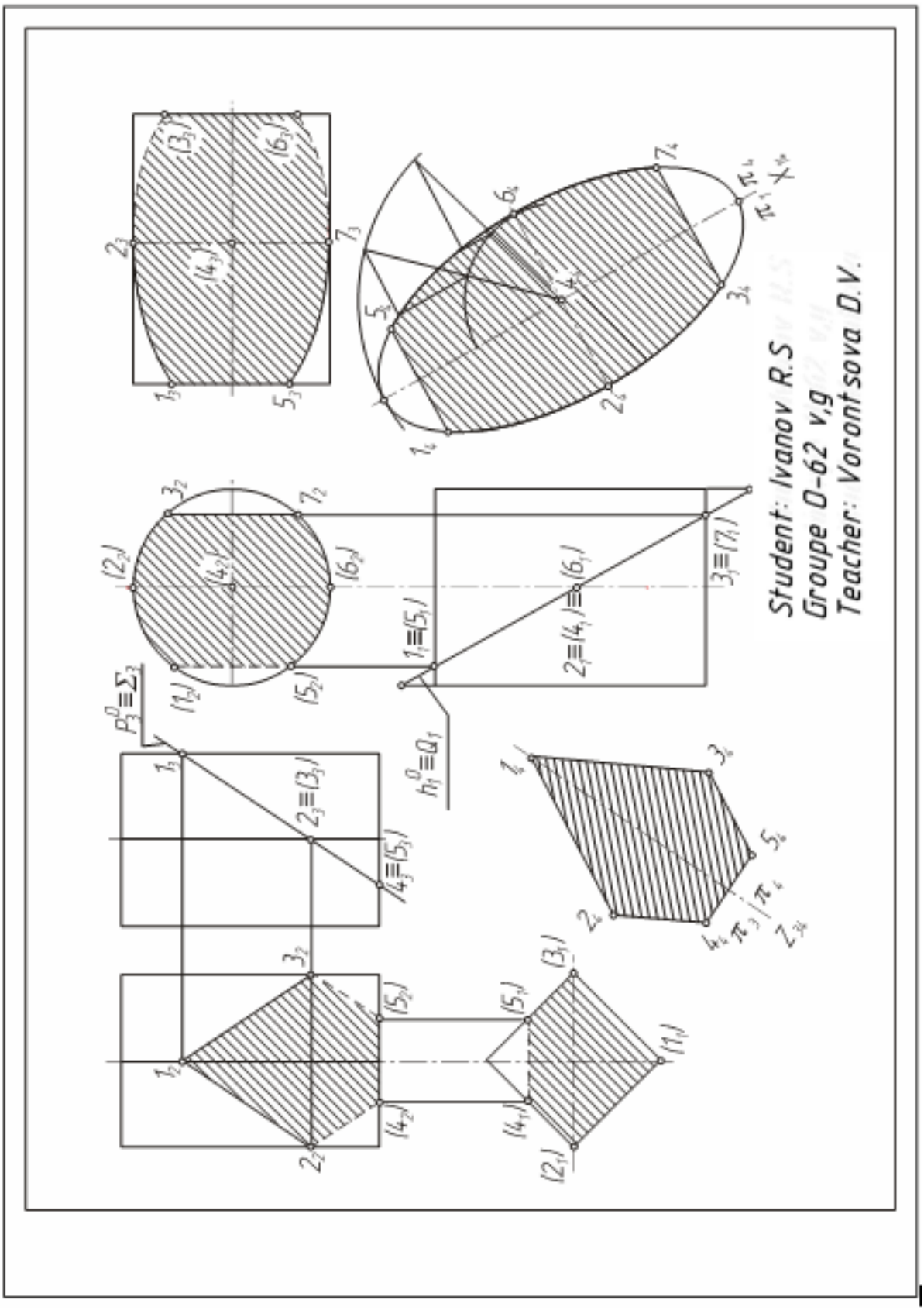
ANNEX 3

The Example of the Task 2 «Point, straight Line, Plane»



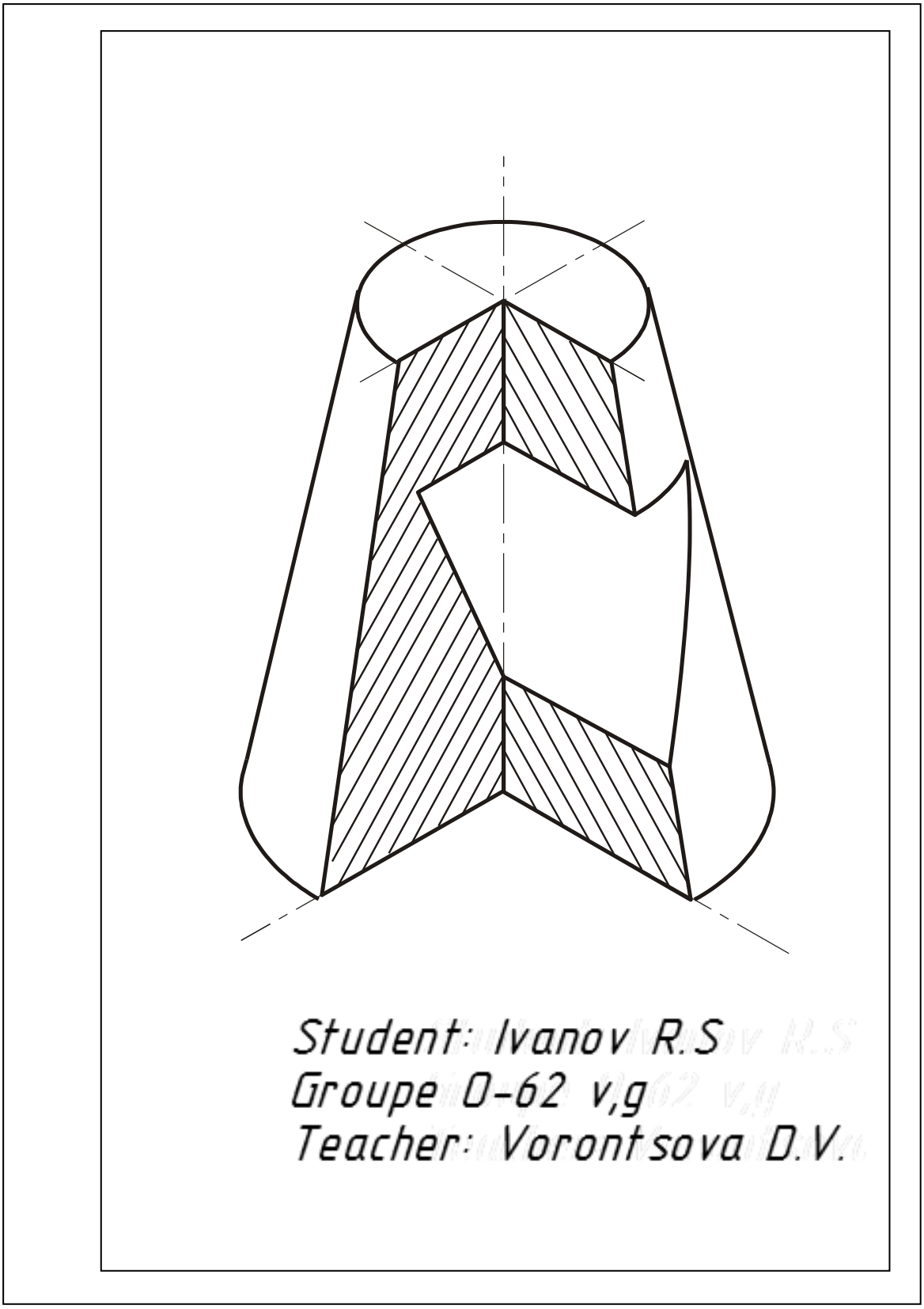
ANNEX 4

Solids and Sections



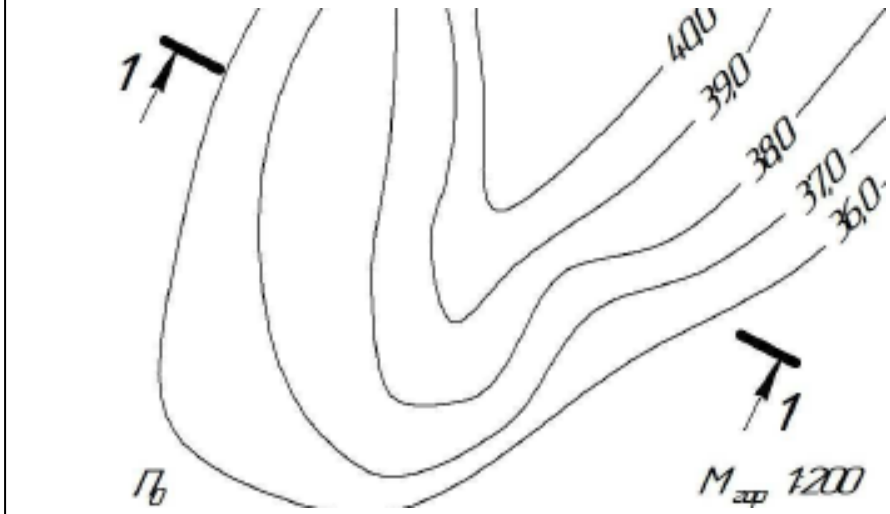
ANNEX 5

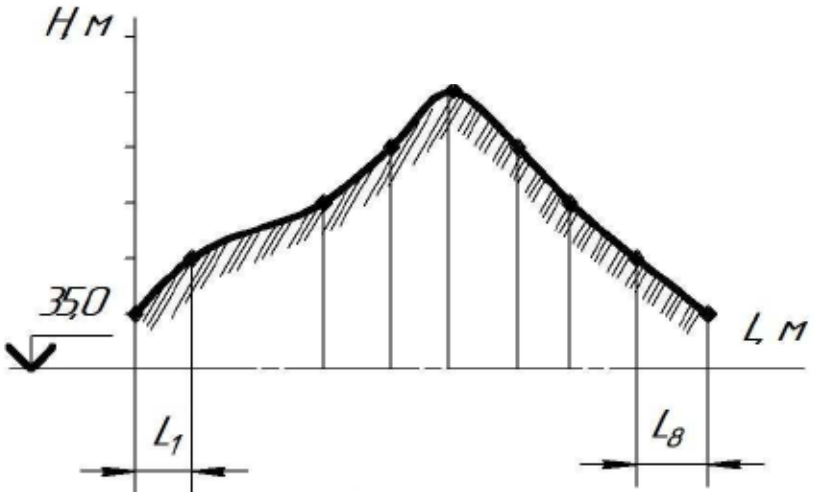
Axonometric drawings



ANNEX 6

Projection of Topographical Surfaces





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Groupe O-62 v,g
Teacher: Vorontsova O.V.

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